THE
INDIAN FORESTER

(FOUNDED IN 1875)

VOL. 125 JUNE 1999 NO. 6

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205/99

14 செப் 1999

ISSN 0019-4816

THE INDIAN FORESTER

Volume 125 **No. 6**

JUNE, 1999

FRONT COVER

TEN-YEAR OLD *DALBERGIA SISSOO* PLANTATION NEAR GORAKHPUR (U.P.)

Photo - J.K. Rawat

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14 செப் 1999

METHODOLOGY FOR SETTING FORESTRY RESEARCH PRIORITIES FOR INDIA

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Introduction

Any research for a good cause is a noble and pious work because it adds to the existing knowledge of humanity. But, due to limited resources in terms of finance, human resources and infrastructure and versatility of these resources to a great extent, research prioritisation occupies central stage of research management. In addition to the need for optimal utilisation of resources, prioritisation is also needed for bringing objectivity in the choice of research and providing a desired direction to research. Further, there are different organisations engaged in carrying out research in forestry in India and therefore, prioritisation in the Indian context may be an attempt to evolve appropriate research portfolio to these organisations on the basis of their capability, preference and potentiality. Similarly prioritisation may be extended to different divisions/wings of the organisation and even to the level of individual scientists. Besides, it should provide mechanism for avoiding duplication of research efforts. Research needs vary from State to State in the country and they are dynamic in nature. Therefore, the prioritisation effort must be able to address spatial and temporal distribution of these needs.

India's forests are famous for their diversity and complexity, which lead to diverse and complex research needs. India's forest ecosystems include tropical, temperate, alpine and arid forests, mangrove and marine ecosystem, etc. The nature of the problem in different ecosystems varies widely. Providing solutions to field problems may be one of the most important issues on which prioritisation process may revolve. Ever increasing demand for forest products and gap between demand and sustainable supply bring the enhancement of productivity into focus. Further, development of contemporary emerging issues in forestry sector, e.g., Joint Forest Management, Biodiversity Conservation, Eco-restoration of degraded forests, Agroforestry, marketing of forest products, Non-Wood Forest Products etc. and developments in contemporary science and technology with high potentiality of application in forestry sector e.g. tissue culture, biotechnology, geographical information system, digital image processing, etc., may play important role in research prioritisation. Research efforts must support achievement of basic objectives of forestry sector, as enunciated in National Forest Policy 1988 (Anon., 1988). In the same policy document some broad priority area of research and development, needing special attention have been identified.

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While developing the methodology for research priorities, the above mentioned basic criteria, basic objectives and special areas must be duly accounted for. Research priorities appear differently to different persons. However, an attempt was made to develop a methodology to prioritise forestry research in India. Before discussing the methodology, it will be pertinent to review the methodology of research prioritisation being followed in some leading organisations.

Contemporary Important Methodologies for Research Prioritisation

Very few organisations have developed methodology for setting their research priorities. However, in due appreciation of the importance of prioritisation, many organisations in India and abroad are trying to develop methodology for this purpose. Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia and Consultative Group of International Agricultural Research (CGIAR) are the most famous organisations for developing specific and independent methodology for themselves for their research prioritisation. The methodology of CSIRO is based on scoring method. It prioritises research purposes of the country on the basis of four criteria, viz., potential benefits, ability to capture the benefit at national level, R&D potential and R&D capacity. The scoring for these four criteria is done on the basis of identification indicators associated with these criteria with respect to each research purpose. Scores of the first two criteria, i.e., potential benefit and ability to capture benefit are multiplied to find the score for attractiveness of the research purpose. Similarly, the score for feasibility is calculated on the basis of other two criteria i.e. R&D potential and R&D capacity. Thus, attractiveness and feasibility are calculated for each purpose. Then each research purpose is plotted on a graph sheet with respect to the area of attractiveness and feasibility and the purposes falling on right hand top corner will have higher chances of getting supported (Brown, 1993).

The Technical Advisory Committee (TAC) of CGIAR has used congruence analysis for prioritisation of research works related to commodities. According to this approach, research should be funded in proportion to the value of production (Anon., 1997). This approach has been strongly advocated in the absence of any other evidence. It suits the difficult area of priority setting (Alston *et al.*, 1995, Anon., 1997). Jha *et al.* (1995) advocated use of modified congruence method for priority setting in research for Indian Agriculture. They modified value of output and incorporated other goals like poverty alleviation, sustainability, export orientation, etc. and calculated final baseline value for each commodity in each State.

In addition to two major attempts towards research prioritisation, there have been various other attempts. Callahan (1981) suggested four criteria viz., response to needs, contribution to productivity and other returns, response to national policies and relation to historical trends for evaluating research programme alternatives for the United States Forest Service. Jakes *et al.* (1989) used modified Delphi exercise for identifying emerging forestry issues in the United States of

America. They involved national forest managers and used questionnaires and discussions to identify the issues. Many organisations follow the basic principle of Management By Objectives (MBO). They identify formally or informally all or few of their vision, mission, goal, objectives, strategies and research activities. Basically their prioritisation attempts revolve around goal setting principle.

Using the concept of operations research techniques of mathematics, coupled with optimisation techniques of economics and management, we may identify seven methods for research prioritisation viz. (i) Checklist Method, (ii) Congruence Method, (iii) Weighted Criteria Method, (iv) Economic Surplus Method, (v) Mathematical Programming, (vi) Econometric Method, and (vii) Simulation Models. They have their own advantages, disadvantages and suitability to particular situations. These methods have been enumerated in ascending order of accuracy. Though the accuracy of the method improves as we move from Checklist Method to Simulation Models, the need for reliable and accurate data also increases. Before discussing a particular method for Indian forestry scenario, it would be essential to review forestry research organisational infrastructure.

Forestry Research Organisations of India

The Forest Research Institute (FRI), Dehra Dun and Centres played a leading role in forestry research. It is generally perceived that Indian forestry research was one of the global leaders in this field till the late sixties and early seventies. Scientific forestry research in India revolved around Silvicultural Conferences, which started in 1918 and were held at intervals of approximately five years. The last three conferences held in 1973, 1980 and 1989 were named as Forestry Conference. These conferences helped FRI & Centers to decide their research portfolio with the active involvement of stakeholders. The participation of resource managers and State Silviculturist in reviewing ongoing research as well as deciding the future direction of research brought in practicality and applicability in choice of research and kept scientists motivated and alert as the output of the research was going to be used. Further, it founded the basic framework of participatory planning, implementation, monitoring and evaluation. Besides, scientists and research managers got excellent support and regard from the field. However, it was generally perceived that the system of coordinated and participatory research system weakened later on.

The Indian Council of Forestry Research .and Education (ICFRE) was constituted by Ministry of Environment and Forests, Government of India as a comprehensive attempt towards reorganisation and revitalisation of forestry research education and training in India. ICFRE was entrusted with the mandate *inter alia*, "To undertake, aid, promote and coordinate forestry education, research and its application". Full autonomy was granted to the Council in 1991. ICFRE has eight institutes and three centres, each one associated with its three institutes.

These institutes have been given territorial jurisdiction to cater to research requirement of a few States. Besides, all State Forest Departments have their research wing. A few States, eg., Madhya Pradesh, Uttar Pradesh, Kerala, Karnataka, Arunachal Pradesh, Jammu &

Kashmir have their own State Forest Research Institute.

In addition to research organisations under forestry sector, there are many Agriculture Universities eg., Tamil Nadu Agriculture University, Punjab Agriculture University, Y.S. Parmar University of Forestry & Horticulture, etc. and Botany Department of a few Universities/Colleges which also carry out forestry research; R&D wings of a few forest-based industries have also emerged as important players in the field of forestry research. Further, national organisations eg., Botanical Survey of India, Zoological Survey of India, Forest Survey of India, Wildlife Institute of India, G.B. Pant Institute of Himalayan Environment and Development, Salim Ali Centre for Ornithology and Natural History, National Institute of Rural Development, etc. have potential and capability for carrying out forestry research. Besides, Indian Council of Agricultural Research (ICAR) has established a network of centres for conducting research on agroforestry and some institutes of ICAR or Council of Scientific and Industrial Research (CSIR), undertake research work which is very important to forestry sector. In this context a methodology for forestry research in India was developed.

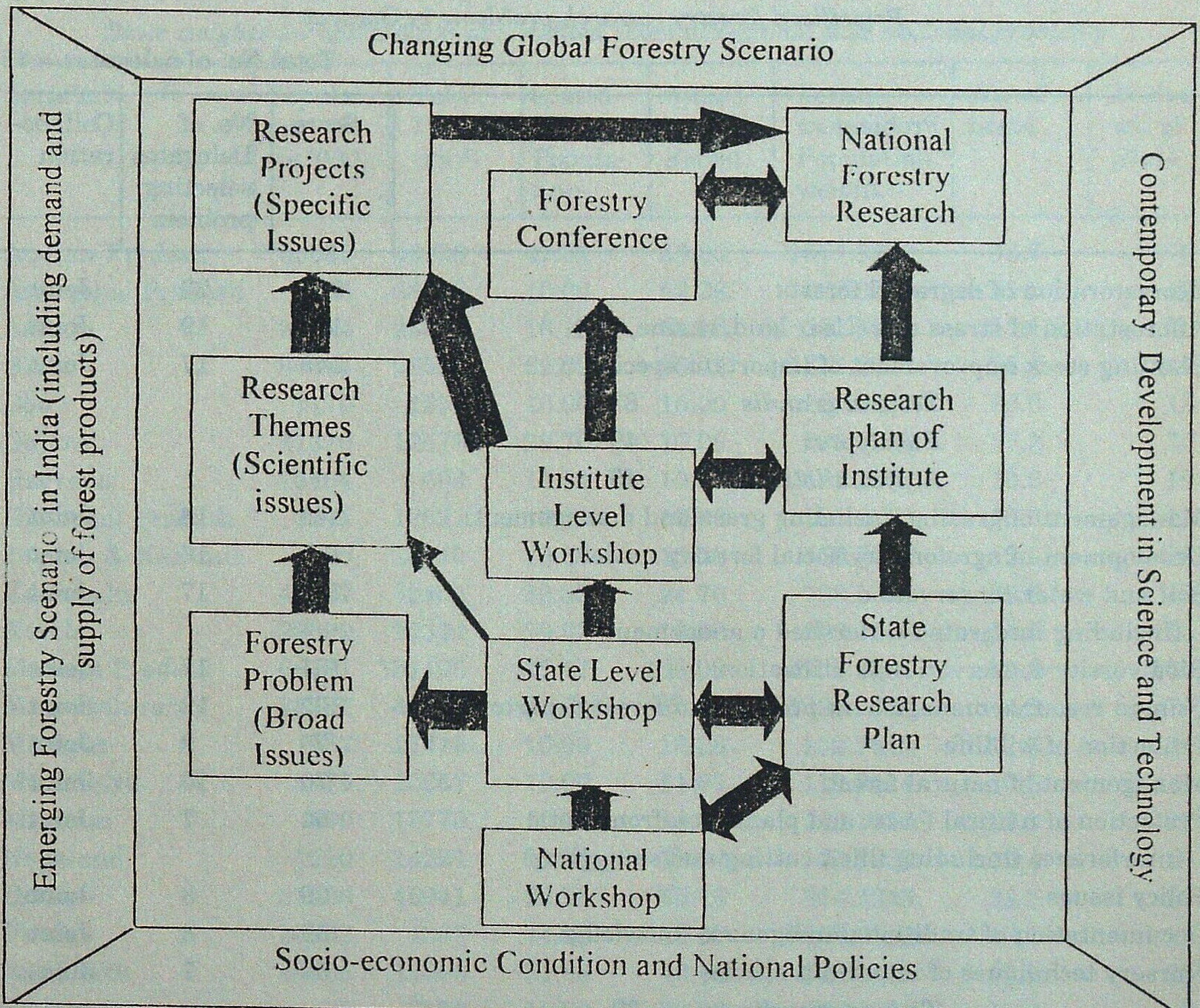
Methodology for Setting Forestry Research Priorities

The methodology provides essentially bottom-up, transparent, participatory and competitive system for setting research priorities. It identifies and prioritises research needs of States, regions and country and focuses research on the needs. The methodology may be schematically shown by the self-explanatory flow diagram at Figure 1.

As shown in the diagram, the methodology ensures three levels of prioritisation viz. prioritisation of research problems as perceived by research users, prioritisation of research themes and prioritisation of research projects, with equitable participation of all groups of stakeholders. It recognises interlinkages among research problems, themes and projects in logical framework and prioritises them in sequential and integrated manner. This methodology was initially developed for ICFRE (Prasad, 1998) and it is being implemented for formulation of National Forestry Research Plan. The collection of data for problems was carried out by using open-ended questionnaire. The data was collected in 27 State-level workshops in 26 States and Andaman & Nicobar. All delegates of the workshop were asked to identify ten research problems of the State and give scores in accordance with the importance of the problem. For the problems related with species, the delegate was requested to identify three species. For better coordination at project level, they were also requested to indicate agency/ agencies most capable for working on solutions. In the prioritisation of the research problems, Delphi Technique was used for arriving at consensus. For better analysis of problems, a suggestive list of problems was also provided in such a manner that not only should it prioritise main problems but also help in identifying possible solutions. For example, the first fifteen research priorities in problem perspective for State of Gujarat have been given in Table 1 whereas the problems upto eighty per cent cumulative score were decided to be enlisted for prioritised list of problems for region and State.

India is a large country with 26 States

Fig. 1


Changing Global Forestry Scenario
Emerging Forestry Scenario in India (including demand and supply of forest products)
Contemporary Development in Science and Technology
Socio-economic Condition and National Policies
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National Forestry Research
Forestry Conference
Research Themes (Scientific issues)
Research plan of Institute
Institute Level Workshop
Forestry Problem (Broad Issues)
State Level Workshop
State Forestry Research Plan
National Workshop

Methodology for setting forestry research priorities for India

and Union Territories (UTs). These States and UTs are of different size and their population varies widely. Therefore, treating them equally for calculation of regional and national priorities might not give a correct picture. On the basis of population and forest cover, 'weight' for each State was calculated as shown in Table 2. Population and forest cover were selected as criteria because population has direct correlation with demand for forest products whereas forest cover represented the management and conservation issues. The scaled weight of population was calculated by taking the weight for the most dominant State for population (i.e. U.P. in this case) as 100 and the weight of other States in this respect was determined in proportion to their population with reference to that of U.P. The minimum of the scaled weight was brought to 10. Similarly, the scaled weight of forest was calculated on the basis of forest cover of M.P. For calculation of weight of State, it was found more appropriate to take square root of the multiplication of the scaled weights.

Table 1

Prioritised forestry research problems in Gujarat

Total No. of delegates = 42

Problem	Score	No. of Delegates selecting problem	Collaboration
Ecorestoration of degraded forests	204	23	Joint
Afforestation of stress site (Usar land, ravine, etc)	166	19	Joint
Planting stock improvement of important species	146	17	Joint
Tectona grandis 83			
Eucalyptus 49			
Acacia nilotica 45			
Management of grazing (including grassland management)	145	18	Joint
Development of agroforestry/social forestry models	135	16	Joint
Soil and water conservation (Including integrated watershed management)	133	17	Joint
Biodiversity conservation & utilisation	131	17	Joint
Human resource management problems of forest department	102	12	Joint
Protection of wildlife	75	9	Joint
Management of natural forest	70	10	Joint
Protection of natural forest and plantation from biotic interference (including illicit cutting and smuggling)	64	7	Joint
Policy issues	59	8	Joint
Documentation of traditional/indigenous knowledge	59	8	Joint
Nursery techniques of important species	57	7	Joint
Tectona grandis 32			
Azadirachta indica 25			
Dalbergia latifolia 17			
Sustainability of forest management/joint forest management	57	7	State

Note - Joint indicates that there is scope of collaborative research projects.

For calculation of regional and national research priorities in problem perspective following formula was used :

$$\text{Weighted score of problem} \quad n = \frac{\dfrac{\Sigma Sn_i}{D_i} \times w_i}{\Sigma w_i} \times 100$$

where,

Sn_i = total score of problem, n in the ith State

D_i = number of respondents in the ith State

W_i = weight of the ith State

After prioritisation of research problem, the prioritisation of research

Table 2

State weights for calculation of weighted score of regional and national problems

State/A.N.	Population* (in '000)	Total Forest** (km^2)	Scaled wt. of Population	Scaled wt. of Forest	Forest weight x Population weight	Wt. of State	Scaled wt. of State
Andhra Pradesh	66508	43290	47.81	33.00	1577.5372	39.7	70
Arunachal Pradesh	865	68602	10.00	52.29	522.9010	22.9	40
Assam	22414	23824	16.11	18.16	292.5851	17.1	30
Bihar	86374	26524	62.09	20.22	1255.2787	35.4	62
Goa	1170	1252	10.00	10.00	100.0000	10.0	18
Gujarat	41310	12578	29.70	10.00	296.9550	17.2	30
Haryana	16464	604	11.84	10.00	118.3507	10.9	19
Himachal Pradesh	5171	12521	10.00	10.00	100.0000	10.0	18
Jammu & Kashmir	7719	20440	10.00	15.58	155.7986	12.5	22
Karnataka	44977	32403	32.33	24.70	798.5348	28.3	49
Kerala	29099	10334	20.92	10.00	209.1768	14.5	25
Madhya Pradesh	66181	131195	47.57	100.00	4757.3897	69.0	121
Maharashtra	78937	46143	56.74	35.17	1995.7428	44.7	78
Manipur	1837	17418	10.00	13.28	132.7642	11.5	20
Meghalaya	1775	15657	10.00	11.93	119.3414	10.9	19
Mizoram	690	18775	10.00	14.31	143.1076	12.0	21
Nagaland	1210	14221	10.00	10.84	108.3959	10.4	18
Orissa	31660	46941	22.76	35.78	814.2943	28.5	50
Punjab	20282	1387	14.58	10.00	145.7962	12.1	21
Rajasthan	44006	13353	31.63	10.18	321.9651	17.9	31
Sikkim	406	3129	10.00	10.00	100.0000	10.0	18
Tamil Nadu	55859	17064	40.15	13.01	522.2664	22.9	40
Tripura	2757	5546	10.00	10.00	100.0000	10.0	18
Uttar Pradesh	139112	33994	100.00	25.91	2591.1048	50.9	89
West Bengal	68078	8349	48.94	10.00	489.3755	22.1	39
Delhi	9421	26	10.00	10.00	100.0000	10.0	18
A&N Islands	281	7613	10.00	10.00	100.0000	10.0	18
					Total	571.3	1000

Source : *Anon., 1991 cited in Anon., 1995
**Anon., 1998

themes was undertaken in the State level workshop. The data for theme was supplemented by selected researchers of ICFRE institutes and research managers. For this a questionnaire, containing a comprehensive list of research themes was used. Themes were basically scientific research aspects of problems in forestry sector. The list was prepared in consultation with scientists working in ICFRE institutes, State Forest Departments and other organisations. These research themes were prioritised on the basis of scores given to each theme by representative group of research users, researchers and research managers. While processing the questionnaires to find out State and country research priorities at State level and national level, equal weight was given to researcher, research user and research manager. While prioritising these themes, their inclusion in short term, middle term and long term was also ascertained. For example the top twenty themes for Gujarat were as given in Table 3. Whereas top hundred themes were sent to each State Forest Department for their consideration for State forestry research plan.

Appropriate prioritisation of research projects is the critical and final outcome of the methodology. The process starts with

Table 3

Prioritised Forestry Research Themes for Gujarat

Rank	Research Theme	Score	Plans*
1	Model for eco-restoration of degraded forests	9.00	LMS
2	Establishment of seed stand/SPA	8.57	LMS
3	Moisture conservation techniques and rain water harvesting	8.18	MS
4	Selection of CPTs and plus trees	8.05	MS
5	Technology development for salt affected areas	7.98	MS
6	Afforestation techniques for MPT	7.87	LMS
7	Formulation, analysis and implementation of National Forest Policy	7.84	LMS
8	Rehabilitation of degraded community lands	7.83	MS
9	Combating desertification/sand dunes/wind erosion	7.78	MS
10	Afforestation on stress/degraded site	7.77	LMS
11	Impact of forest degradation on bio-diversity	7.74	LM
12	Survey of rare and endangered medicinal and aromatic plants	7.71	MS
13	Management of bio-diversity reserves	7.69	LMS
14	Afforestation technique on problem sites	7.66	LMS
15	Modernising procedure for working plan	7.65	LMS
16	Cultivation methods of medicinal plants, their market demand and user agencies	7.63	MS
17	Development of seedling seed orchards and clonal orchards	7.63	LMS
18	Watershed management practices	7.62	MS
19	Wildlife and Management of national parks and sanctuaries	7.57	LMS
20	Processing, marketing and export of NWFP	7.57	MS

Note: * L = Long Term; M = Middle Term; S = Short Term the identification of projects. The deliberations in the workshop for deciding project portfolio may bring transparency, accountability and confidence building for collaborative work. The process of participatory research planning may take the research a long way towards objectivity, quality and applicability. Further, the prioritised result of research problems and themes may provide additional help in deciding project portfolio. Using concept of qualitative and quantitative market research, solutions to the research problems identified at State level, regional level and national level, in terms of specific projects may be identified through the deliberations in State level and institute level workshops. For identifying projects, a few research problems may be grouped together to facilitate the analysis. For the State of Gujarat, for example, few important research projects could be as follows :

- To develop area-specific economically viable model for eco-restoration of degraded forests in different forest types.
- To develop comprehensive technology for afforestation in salt affected area (Kutch area)
- To conduct multi-locational trial of different clones of *Tectona grandis*, *Eucalyptus*, *Acacia nilotica* and *Azadirachta indica* to identify best clones in each zone.
- To develop appropriate moisture conservation technique for Saurashtra area.
- To assess problem of grazing and develop management practices with people's participation to manage incidence of grazing.
- To develop comprehensive agro-forestry model (including cost benefit analysis and marketing of products) in different agro-climatic zones.
- To carry out ethno-botanical study in important tribal area.
- To study and standardise management practices of marine ecosystems.
- To carry out ecological study for finding alternative home of Lion.
- To conduct market study of medicinal plants.
- To study impact of degradation of forest area on bio-diversity.
- To develop mechanism for incorporation of socio-economic and environmental issues in formulation of working plan.
- To establish seedling seed orchard and clonal orchard of priority species.
- To study impact of other policies eg., industrial policy, economic policy on forestry.
- To develop monitoring indicator for Joint Forest Management.
- To develop bio-diversity indices for critical areas.

On the basis of mandate and existing strength, every research organisation should develop criteria for setting research priorities of research projects. Depending upon nature of operation and stakeholders, a questionnaire may be used for arriving at a set of ten criteria along with their scaled weight. A few criteria, eg. User's need, importance of research themes, scientific advancement and scientific leadership to the organisation could be selected as essential criteria and remaining six have to be selected carefully. In case of ICFRE, the criteria given in Table 4 were selected with the help of a questionnaire. These criteria may be used for calculation of index score for each project. On the basis of scoring by appropriately constituted Research Advisory Group (RAG) attached to each institute as shown for an example project in Table 4, research projects may be

Table 4

Criteria and weights for prioritisation of projects and example of Eucalyptus hybridization project

Description	Scaled Weight	Score of RAG
User's needs (State research problem)	13.7	9
Importance of research theme (priority of research area)	12.7	9
Scientific advancement	12.3	8
Scientific leadership to the organisations	11.3	8
Bio-diversity conservation	10.0	0
Sustainable forest development	9.3	6
Economic benefit (increase in productivity)	8.8	10
Linking people with forestry	8.4	5
Improvement in environment quality	7.8	5
Poverty alleviation (creation of employment opportunity)	5.7	4
Total	100.0	

prioritised. RAG members may be requested to keep basic objectives of National Forest Policy 1988, research priorities in problem and the perspectives in mind while scoring against criteria for project prioritisation.

Index score of a project = $\sum w_i S_i$;
Where,
W_i = weight of ith criterion,
S_i = average score of RAG against ith criterion for the project.

Index score of the project
= 13.7*9 + 12.7*9 + 12.3*8 + 11.3*8 + 10*0 + 9.3*6+ 8.8*10 + 8.4*5 + 7.8*5 + 5.7*4

= 123.3 + 114.3 + 98.4 + 90.4 + 0 + 55.8 + 88 + 42 + 39 + 22.8

This score may be used for prioritisation of research projects in an organisation/division. It is important to note that same set of criteria and weight and same group of RAG may be used for the prioritisation of projects. In case of different set of RAG their scores have to be normalised. The weighted criteria method is generally perceived as an inferior method as compared to few other methods. But, given the diversity of forestry in India and non-availability of reliable and accurate data in terms of research input, output, adoption rate, etc., weighted criteria method was found to be the most appropriate method for the determination of priorities. Some percentage, say ten per cent may be kept for those strategic projects which may not come above in the prioritised list of projects whereas otherwise they are important.

The methodology envisages formulation of State Forestry Research Plans (SFRP), research plans of institutes and National Forestry Research Plan as shown in Figure 1. These plans must incorporate the State, regional and national priorities. In SFRP, State Forest Departments must identify research projects and clearly spell out the projects which they are going out to carry out on their own, what they expect from other institutes in terms of collaborative projects or independent projects, to be taken-up by institutes. Research plan of ICFRE institutes must incorporate projects according to State and regional priorities and State Forestry Research Plan of States under their jurisdiction. It should also take into account the work of sister organisations in the area. Further, these plans may be formulated with intensive and extensive environmental analysis. The analysis may take into factors eg., emerging national and global forestry scenario, socio-economic condition and national policies and contemporary developments in science and technology. India's forests consist of diverse and complex ecosystem. Taking global scenario into account will help forestry research in India to play a leading role at global level. Taking into account socio-economic condition and emerging national scenario would help in focusing research to needs and make it more meaningful. There has been contemporary scientific and technology development eg., Geographic Information System (GIS), Digital Image Processing (DIP), Tissue Culture, Bio-fertilizers, Bio-technology, Social and Livelihood Analysis, etc. It is high time India's forestry research should come out of the straitjacket of typical silviculture and take advantage of contemporary developments in science and technology. In temporal perspective, the plans must contain short term, middle term and long term plans. Short term, middle term and long term may contain specific projects whereas long term plan may contain Vision Statement as is done in case of perspective planning.

The formulation of and deliberation on plans in transparent manner aims at avoiding duplication of work and initiation of extensive collaboration and thereby ensuring optimum utilisation of resources. Further, a few divisions of the institutes may be identified as Centres of Advanced Studies for specific research area. These centres may be identified on the basis of past achievements, existing strengths and need for in-depth research, etc. These centres must address the important priorities of the country, important global issues and may act as nodal centres for intensive research in their area. Most importantly participation of research organisations, research users and research managers in the deliberations in the workshops shall lay a strong foundation of symbiotic networking and collaborative works. This networking is envisaged at national level, regional level and State level with ICFRE, ICFRE institutes and State Forest Departments as nodal agencies, respectively. The coordination and collaboration may be institutionalised with the help of a Core Group for Research Coordination at each level. Besides, it may also promote healthy scientific exchange among different organisations. Depending on the spatial distribution and emergence of priorities, a few important research areas eg., planting stock improvement, agro-forestry, bio-diversity conservation could be identified and nationally coordinated projects might be formulated in these areas. The analysis of priorities in problem and thematic perspective may provide project hierarchy i.e., State level projects, regional projects and nationally coordinated projects. Further, problems and themes with unusual high score or high score in large area may advocate for aggressive and proactive research so that before these problems may cause serious damage, appropriate technology to address the problems may be the developed. These priorities shall form the basis for selection of new projects to be undertaken. Besides, these priorities shall provide basis for reviewing ongoing projects for their continuation.

There is a need for frequent meetings of senior managers of national forestry research organisations for developing, nurturing and maintaining symbiotic networking. In such meetings, representative of ICAR and a few other organisation eg., NEERI (National Environment Engineering Research Institute) may also be invited. These meetings may be arranged twice a year to review and balance project portfolio in accordance with priorities, capability, potentiality and preference of the organisation. India is a vast country with a chain of universities. There is very high potentiality of research in Departments of Botany, Zoology, Agriculture Science, etc. of these universities. Their talents may be utilised by sponsored projects. In the area of priorities not being duly covered by other research organisations and particularly the short term, projects may be sponsored to universities, State Forest Departments, other organisations on the basis of open competition.

India has been able to manage forestry research in the past with Silvicultural Conference/Forestry Conference. There is a strong need to revive the system to determine project portfolio, identify research needs and review the ongoing projects. Forestry Conference may be revived in 1999. The conference must deliberate on the draft National Forestry Research Plan (NFRP) in detail and come out with the most comprehensive and need based NFRP. To avoid duplication, a project database of on going projects may be prepared and kept on line.

Conclusion

Change is the law of nature. A sector, organisation or individual shall lose relevance and effectiveness, if it/he does not change with time. It is obvious that the methodology discussed above will strive to introduce comprehensive change in existing forestry research system. Therefore, managing the change shall be the key to the success of the methodology. Hopefully, this methodology shall be able to establish transparent, participatory and competitive system. Moreover, it will be able to achieve consonance among complex and diverse research needs; capability, potentiality and preference of researcher; objectives and structure of individual organisation. Besides, it will promote innovation and passion for excellence.

Getting researchers, research managers, research users and research organisations agreeable for adoption of this methodology shall remain a challenging task. Further, successful implementation of this methodology needs very skillful and knowledgeable management because many organisations work independently and any element of imposition through bureaucratic means may face adverse reaction which may cause further alienation. Therefore, developing symbiotic networking may not be an easy task. However, this is a challenge, worth taking. The research carried out with the priorities set by the methodology shall be able to meet the research needs of States and the country and contribute significantly to advancement in forestry sector in India.

SUMMARY

Setting research priorities stands for selecting balanced research portfolio with due consideration to the research needs, optimum utilisation of resources and capability, potentiality and preference of scientists. It has also been observed that many organisations working on the same fields may not have coordination and collaboration. Further, the choice of research lacks in objectivity. Therefore, there is need for developing a methodology for setting research priorities in forestry sector for India. Till date very few organisations have developed such methodology. In this context a comprehensive methodology, compatible to Indian forestry research objectives and infrastructure, was developed. The methodology is being implemented for formulation of National Forestry Research Plan. The methodology is basically a modified bottom-up approach and follows Weighted Criteria Method for research prioritisation and Delphi Technique for reaching consensus. It ensures three levels of prioritisation i.e. prioritisation of problems, themes and projects in integrated and sequential manner. It uses open-ended questionnaires, deliberation in series of workshops and scoring by well informed Research Advisory Group for setting research priorities. It ensures formulation of State Forestry Research Plan, Research Plan of Institutes and National Forestry Research Plan in sequence with very high degree of transparency and participation. These plans are being formulated with in-depth environmental analysis. The methodology focuses research to research needs. It also provides a mechanism for establishment and institutionalisation of symbiotic networking of forestry research organisations. It establishes transparent, participatory and competitive research management system. Further, it creates an environment which will promote passion for innovation and excellence in researchers.

भारत में वानिकी अनुसंधान की पूर्वताएँ निश्चित करने का रीतिविज्ञान

बाला प्रसाद व अनसूया नेगी

सारांश

अनुसधांन की पुर्वताएँ निश्चित करने से तात्पर्य है अनुसंधान, आवश्यकताओं संसाधनों का इष्टतम उपयोग करने तथा वैज्ञानिकों की योग्यताओं, संभावनाओं और अधिमान्यताओं पर पूरा-पूरा ध्यान देते हुए अनुसंधान कार्यों का संतुलित चुनाव करना । ये भी देखने में आया है कि बहुत संगठनों में जो एक ही कार्य क्षेत्र में लगे हुए होते हैं, परस्पर समन्वय और सहयोग ही नहीं होता। इसके अतिरिक्त अनुसंधानों का चुनाव करने में वस्तुनिष्ठता का आभाव रहता है । इसी कारण से भारतवर्ष में वानिकी क्षेत्र की अनुसंधान पूर्वताएँ निश्चित करने के लिए रीतिविज्ञान विकसित करने की आवश्यकता रही है । अभी तक बहुत कम संगठन ऐसे हैं जिन्होंने ऐसा कोई रीतिविज्ञान विकसित किया है । इसी संदर्भ में भारतीय वानिकी अनुसंधान के उद्देश्यों और उसकी अधोसंरचना से संगति रखने वाले एक सर्वसमावेशी रीतिविज्ञान का विकास किया गया है । इस रीतिविज्ञान का क्रियान्वयन राष्ट्रीय वानिकी अनुसंधान योजना तैयार करने के लिए किया जा रहा है । आधारतः यह रीति विज्ञान नीचे से ऊपर की ओर जाने वाला, संशोधित अभिगमन है और पूर्वता निर्धारण के लिए भारित कसौटियों की रीति और सर्वसम्मति लाने के लिए डेल्फी प्रविधि का अनुसरण करता है । इसमें पूर्वता निर्धारण के तीन स्तर सुनिश्चित किए गए हैं अर्थात् समस्याओं, विषयों और परियोजनाओं का एकीकृत करते हुए क्रमिक रूप से पूर्वता निर्धारण करना । इसमें अनुसंधान पूर्वताएँ निश्चित करने के लिए बाहर की ओर खुली प्रश्नावलियाँ, कार्यशालाओं की शृंखला में विचार विनिमय और भली-भाँति सूचनाओं से लैस अनुसंधान परामर्शदातृ समूह द्वारा क्रमांकन उपयोग में लाया गया है । इसमें राज्य वानिकी अनुसंधान योजना, संस्थानों की अनुसंधान योजना और राष्ट्रीय अनुसंधान योजनाओं का अनुक्रम से बनाया जाना सुनिश्चित किया गया है जिनमें अत्यधिक मात्रा में खुलापन और सहभागिता रखी गई है । ये योजनाएँ गहराई से पर्यावरणिक विश्लेषण करने के उपरान्त तैयार की जाती हैं । रीतिविज्ञान में अनुसंधान आवश्यकताओं पर गवेषणा करने पर ध्यान दिया जाता है । इससे वानिकि में अनुसंधान करने वाले संगठनों को सहजीवी जालक्रम में स्थापित होने और संस्थावद्ध बनने की यन्त्रकार्यता भी मिल जाती है । इससे पारदर्शी, सहयोगात्मक और प्रतिस्पर्धा अनुसंधान प्रबन्ध प्रणाली भी स्थापित हो जाती है । इसके अलावा, इससे ऐसा वातावरण भी तैयार हो जाता है जिसमें अनुसंधानकर्ताओं को नवीनताएँ लाने और अत्युत्तमता की ओर बढ़ने की लगन और प्रेरणा मिलती है ।

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A SIMPLE METHOD OF ASSESSING GROWING STOCK AND ANNUAL INCREMENT FOR PREPARING JFM PLANS

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Introduction

There is a growing recognition that sustainable Forest Management necessitates a meaningful involvement of forest communities in Joint Forest Management (JFM) exercise. The Ministry of Environment and Forests came out with a new National Forest Policy in 1988 and one prime component of the Policy emphasizes that "The people will be actively involved in protection, conservation and management of forest". In this view, the successful implementation of Joint Forest Management (JFM) plans will be needed at village level, where a simple method is needed for assessment of Growing Stock (G.S.) and Mean Annual Increment (M.A.I.) which are the back-bone for any plan of sustainable management of forests.

Assessment of G.S. and M.A.I. is the pivot for any successful scheme for sustainable management of forests, but no simple method has so far been evolved. Moreover for the use of even field level junior forester too, the established conventional methods of finding G.S. and M.A.I. are complicated and not very practical, particularly for the conditions where Micro Management Plan is to be prepared at village-level with active participation of local villagers. Taking this general hardship into account, on the basis of some guidelines mentioned in *Field Methods Manual* Vol. I (Poffenberger *et al.*, 1992), a very simple method of finding G.S. and M.A.I. is being described here. Here the effort has been made to avoid all the complications and difficulties normally arising in practical assessment of G.S. and M.A.I., and all possible effeorts have been made to make this exercise simple and easy. It is hoped that the method described can prove very useful and most practicable in the field, particularly in Joint Forestry Management Micro-plans preparation exercise.

Principle

Annual Increment in G.B.H. of a tree varies with species to species and also with the age of the tree. But, when mean G.B.H. of a tree of the crop is observed, we see that Mean Annual Increment in mean G.B.H. of each tree is uniform irrespective of species and age of crop and this is the basic principle applied here in this method.

Methodology

(a) *To find Growing Stock* : This method can be used only in those forest areas where some Coppice Crop i.e. previously harvested coppice coupes are available in the same

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forest. We select sample plots of size 50 m x 20 m, two to three in number per hectare in the forest in such a way that these plots are the representative of the forest crop. Now do the 100% enumeration and collect the following data from field for each of the sample plots :

Plot No.

No.	G.B.H.	Total GBH (m)	Average GBH per tree (m)

Now Mean GBH per tree =

$$\frac{\text{Sum of the average GBH per tree in respect of each plot}}{\text{Total number of sample plots.}}$$

Therefore, Mean B.A per tree =

$$\frac{(\text{Mean GBH per tree})^2}{4\pi}$$

And average number of trees per ha =

$$\frac{\text{Sum of total number of trees of each plot}}{\text{Total number of Plots}} \times 10$$

Now Mean B.A. per ha = Mean B.A. per tree x Av. number of trees per ha

We know that $\text{G.S.} = b + a\,(\text{B.A. m}^2\text{ per ha})^2$ tonnes (*Field Methods Manual* Vol-1.)

Where, $b = 35.23$

$a = 0.156$

Thus putting the value of Mean B.A per ha, we find the growing stock of the forest in tonnes. This G.S. is the total biomass of the forest.

(i) If this G.S. consists of stem timber as well as small wood, then

$$\text{G.S.} = \frac{b + a\,(\text{Mean B.A. m}^2\text{ per ha})^2}{0.74}\ \text{m}^3$$

Here assuming density of stem timber and small wood = 0.74 tonnes/m^3

(ii) and if this G.S. consists of small wood only, then

$$\text{G.S.} = \frac{b + a\,(\text{Mean B.A. m}^2\text{ per ha})^2}{0.25}\ \text{m}^3$$

Here assuming density of small wood = 0.25 tonnes/m^3

(b) *To find Mean Annual Increment* : First we select a Coppice Coupe available in the forest i.e. the coupe which was exploited some years ago and now consists of Coppice growth. Now as above, select the sample plots in Coppice Coupe and do the 100% enumeration and record data for each of sample plots as follows :

Plot No.

No.	GBH	Total GBH (m)	Average GBH per coppice (m)

Now Mean GBH of a coppice growth =

$$\frac{\text{Sum of Av. GBH per coppice in respect of of each Plot.}}{\text{Total No. of Plots.}}$$

Therefore MAI in Mean GBH per Coppice growth =

$$\frac{\text{Mean GBH per Coppice growth}}{\text{Age of the Coppice Crop}}$$

Where age of the Coppice crop is the total years elapsed after the Coupe was exploited.

Now since it is assumed that MAI in Mean GBH of each tree is uniform, irrespective of species and age of the crop, therefore, MAI in Mean GBH per tree of the forest will be equal to the MAI in Mean GBH per Coppice Growth of the Coppice Crop.

Hence, MAI is Mean GBH per tree of the forest =

MAI in Mean GBH per coppice growth of the Coppice Crop.

Thus, MAI in Mean BA per tree of the forest =

$$\frac{\text{MAI in Mean GBH per tree (2 x Mean GBH per tree + MAI in Mean GBH per tree)}}{4\pi}$$

Therefore, MAI in Mean B.A. per ha of forest =

$$\frac{\text{MAI in Mean GBH per tree (2 x Mean GBH per tree + MAI in Mean GBH per tree)}}{4\pi} \times \text{Average No. of trees/ha}$$

Therefore, MAI in G.S. =

a x MAI in Mean BA/ha (2 x Mean BA, per ha + MAI in Mean BA per ha) tonnes

a = Constant = 0.156

(i) If G.S. consists of stem timber and small wood, then

MAI in G.S. =

$$\frac{\text{a x MAI in Mean B.A./ha (2 x Mean B.A. per ha + MAI in Mean B.A. per ha)}}{0.74}\ \text{m}^3$$

Assuming density of stem timber and small wood = $0.74/\text{m}^3$

(ii) and if G.S. consists of small wood only, then

MAI in G.S. =

$$\frac{\text{a x MAI in Mean B.A/ha (2 x Mean B.A/ha + MAI in Mean B.A per ha)}}{0.25}\ \text{m}^3$$

In Piprahi forest of Garhwa South Forest Division, an exercise to find the exiting G.S. and MAI was conducted and worked out as follows :

Av. No. of Trees/ha = 470

Mean B.A./tree = $0.023\ \text{m}^2$

Mean B.A./ha = 0.023×470
= $10.81\ \text{m}^2$

G.S. = b + a (Mean B.A m^2/ha)^2 tonnes
= $35.23 + 0.156\ (10.81)^2$ tonnes
= 53.459 tonnes per ha
= 53.459/0.74 m^3/ha
= 72.24 m^3/ha

Table 1

No. of the Coppice Coupe	Age of the Coppice Coupe (yrs)	Mean GBH per Coppice growth (m)	MAI in Mean GBH per Coppice growth (m)
1.	8	0.27	0.333 or say 0.03
2.	9	0.23	0.026 or say 0.03
3.	12	0.35	0.029 or say 0.03
4.	10	0.32	0.032 or say 0.03
5.	12	0.42	0.035 or say 0.03
6.	10	0.27	0.027 or say 0.03

This G.S. consists of stem timber as well as small wood.

and MAI in G.S. =

a x MAI in Mean B.A/ha (2 x Mean B.A./ha in m^2 + MAI in mean B.A per ha)
= 0.156 x 1.081 (2 x 10.81 + 1.081) tonnes/ha

= 3.827 tonnes/ha
= 3.827/0.74 m^3/ha
= 5.17 m^3/ha

Assuming density of timber and small wood = 0.74 ton/m^3

Thus MAI in G.S. is 7.1% of G.S.

To verify the above described methodology and principle mentioned here in this method, six different coppice coupes were selected and data collected. Thus tabulated and compiled data for each of the Coppice coupes is given in Table 1.

Table 1 shows that MAI in Mean GBH per Coppice growth of Coppice Crop of different age is almost equal.

Advantages

(i) The method is very simple.

(ii) Proper height measurement is a very tedious job even for the field foresters but this method does not need height.

Notations :-

G.S. = Growing Stock.
B.A. = Basal Area.
GBH = Girth at breast height i.e. at 1.37 metre of height.

Acknowledgements

The authors are grateful to Shri A.K. Singh, Conservator of Forests, Social Forestry, Ranchi and Shri B.A. Khan, Conservator of Forests, State Trading Circle, Daltonganj, for their valuable suggestions.

SUMMARY

A very simple method of finding growing stock and MAI have been described in this paper. Efforts have been to avoid all complications and difficulties normally arising in their practical assessment.

जेएफएम (एकीकृत वन प्रबन्ध) योजना तैयार करने के लिए वर्धीसंनिधि और वार्षिक संवृद्धि का आकलन करने की सरल रीति

एच०एस० गुप्त व के०के० त्रिपाठी

सारांश

वर्धीसंनिधि और माध्य वार्षिक संवृद्धि मालूम करने की एक बहुत सरल विधि प्रस्तुत अभिपत्र में वर्णित की गई है । इसमें सभी तरह की जटिलताओं और कठिनाइयों से बचने का प्रयास किया गया है जो सामान्यतः उनको व्यवहार में आकलन करते समय सामने आती हैं ।

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RESPONSE OF FUNGICIDES AND ANTIBIOTICS AGAINST ANTHRACNOSE OF POPLAR CAUSED BY *COLLETOTRICHUM GRAMINICOLUM*

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Introduction

Intensive culture of trees to provide economical woody biomass for fibre and energy has recently received much attention in the North-Central United States (Hansen *et al.*, 1993). Intensive management of plantations of rapidly growing genetically improved trees can maximize fibre production. *Populus* is well suited for management and utilization because of its rapid growth, genetic diversity, ease of vegetative propagation, coppice regeneration and suitability for energy and industrial uses.

Intensively cultured Poplar plantations are expensive to establish and maintain (Rose *et al.*, 1981) thus it is important that they be protected from disease and insect injuries. Planting clones with a high degree of resistance to pathogens is the best preventive management strategy. In this paper, we report Anthracnose of Poplar, a disease which is highly harmful in Uttar Pradesh, especially in Tarai region.

Materials and Methods

Collection Anthracnose infected leaves of Poplar : Infected leaves of Poplar clone G-3 exhibiting the typical symptoms of Anthracnose infection were collected from the Research and Development Centre, Wimco Seedlings Limited, Rudrapur, U.S. Nagar.

Isolation of the fungus : The pathogen *Colletotrichum graminicolum* was isolated from infected leaf plant part during 1997 Kharif season. Infected leaves of the plant bearing spots were cut into small pieces of 2 or 3 mm size showing half healthy and half diseased tissues with the help of a previously sterilized blade. After surface sterilization with $HgCl_2$ solution (1:1000) for 30 seconds, the infected pieces were thoroughly washed 3 times in sterilized distilled water. These pieces were then transferred on plants/petri plates containing potato dextrose agar medium in an inoculation chamber under aseptic condition, followed by incubation at 25 ± 1°C. After 72-86 hours of incubation, the fungal growth was identified morphologically and microscopically.

Screening of the fungicides and antibiotics under in-vitro conditions : Poisoned food technique was followed to test *in-vitro* activity of the fungicides and antibiotics against the fungus *C. graminicolum*. All the fungicides and antibiotics were tested at differenct concentrations.

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Preparation of different concentrations of fungicides and antibiotics stock solution/ suspension : The different fungicides and antibiotics used were Bavistin 50 WP, Indofil M-75 WP, Ziram 80 WP, Fytolan 50 W.P. Captan 80 WP, Topsin M 70 WP, Vitavax 75 WP, Aureofungin, Tetracycline, Streptomycin and Dicristicin. Eight ml PDA (potato dextrose agar) was poured in Corning flasks of 250 ml capacity and sterilized. Stock solutions of 5000 ppm for all the above given fungicides and antibiotics were prepared. Concentration of all fungicides were 10, 50, 100, 200, 250 and 500 ppm based on active ingredient. In the case of antibiotics, concentrations were kept same as fungicides except 200 ppm. Concentrations were prepared by adding measured quantity of the fungicides and antibiotics. Stock solutions were calculated by the formula :

$$N_1V_1 = N_2V_2$$

where

N_1V_1 = Strength and volume of PDA
N_2V_2 = Strength and volume of stock solution.

The measured quantity of stock solution calculated from the above formula was mixed in flasks containing 80 ml PDA. For the prepared stock solution of 5000 ppm the lower concentrations were prepared by adding amount of sterilized distilled water in determined amount of the stock solution.

Poisoned Food Technique : This technique was followed to examine the effect of various fungicides and antibiotics on mycelial growth of the fungus. In case of fungicides PDA, and in case of antibiotics basal medium was taken.

Sucrose - 50 gm
KNO_3 - 10 gm
KH_2PO_4 - 5 gm
$MgSO_4$ - 2.5 gm
$FeCl_2$ - 0.02 gm
Distilled water - 1000 ml

Measured quantities of the fungicides/ antibiotics were added in sterilized PDA/ basal medium to get desired concentration. In case of check, instead of fungicides/ antibiotics only sterilized distilled water was added. The medium was then poured into sterilized petri dishes (90 gm) and allowed to solidify. After solidification, the plates were inoculated with 5 mm discs cut from 7 days old culture of the test fungus. The mycelial disc was then kept in an inverted position so that the fungus came in direct contact with the poisoned medium. Three replications of fungicides and four replications of antibiotics were maintained for each treatment along with control. The petri plates were incubated at 25 ± 1°C for 5 days. The radial growth of the colony was measured and average of three replication were taken in case of fungicides, four for antibiotics. The per cent inhibition of growth in each treatment was calculated by the equation :

$I = C - T / C \times 100$
I = Inhibition
C = Colony diameter in check
T = Colony diameter in treatment

Spore Germination Test

A. *Relative tolerance of the spore of test fungus to fungicides* : The efficacy of different fungicides were tested at varying concentrations 10, 50, 100, 200, 250 and 500 ppm in cavity slides. Slides were washed with water, spirit and then sterilized. The amount of spore suspension and fungicides solution was deposit in small drops (0.5 ml) in the cavity glass slides. The slides were incubated at 25 ± 1°C in humid atmosphere for 20 hours. Four replications of each treatment were maintained. After the incubation period the slides were dried at room temperature and germinated spores were counted under compound microscope. The per cent inhibition of spore germination was calculated as follows :

$$\text{Per cent inhibition of spore germination} = \frac{\text{No. of spores germinated in check} - \text{No. of spores germinated in treatments}}{\text{No. of spores germinated in check}}$$

B. *Relative tolerance of the spore of the test fungus to antibiotics* : The efficacy of Tetracycline hydrochloride, Streptomycin sulphate, Dicristicin and Aureofungin were tested at varying concentrations 10, 50, 100, 200, 250 and 500 ppm. There were three replications for each treatment and observations were recorded at definite periods. The per cent inhibition of spore germination for various antibiotics at different concentrations was calculated using the formula as described in (A) above.

Results and Discussions

Screening of the fungicides in-vitro : Out of nine fungicides the more inhibitory effect was observed in Bavistin, Topsin-M and Vitavax. These three fungicides were found highly toxic against *C. graminicolum* at all six concentrations. Captan and Ridomil M2 significantly inhibited the mycelial growth of the fungus (Tables 1 and 2). Indofil M-45, Ziram and Bayleton were found less effective but caused significant inhibition at all six concentrations. Bavistin at 50, 100, 200, 250 and 500 ppm; Topsin - M at 200, 250 and 500 ppm inhibited the mycelial growth of *C. graminicolum* by more than 80 per cent but less than 100 per cent. Captan at 500 ppm, Vitavax at 250 and 500 ppm inhibited the mycelial growth by more than 60 % but less than 70 %. At 200, 250 and 500 ppm of Captan, 100, 200, 250 and 500 ppm of Ridomil Mz, 200 ppm of Vitavax inhibited the mycelial growth of *C. graminicolum* by more than 50 % but less than 60 %.

Effect of fungicides on spore germination : Eight systemic and non-systemic fungicides were evaluated for their effects on spore germination of *C. graminicolum*. For each fungicide, six concentrations were taken. The results obtained are given in Table 3. It was observed that as the concentration of fungicides increased there was corresponding increase at the level of inhibition. Lower concentrations were relatively less effective except for Bavistin (Carbendazim) and Topsin-M (Thiophanate Methyl) which effectively reduced spore germination by 95.82 per cent and 25-30 per cent, respectively at 10 ppm. Remaining fungicides at 10 ppm concentration reduced germination only about 15-22 per cent. However, reduction in growth was found to be significantly different from that of control and also between the fungicides. At the concentration of 50 ppm, Bavistin (Carbendazim) and Topsin-M (Thiophanate Methyl) reduced germination by more than 96 per cent, while other fungicides could

Table 1

Effect of different fungicides on the radial growth inhibition of C. graminicolum

Name of the fungicides	Radial growth inhibition (mm)					
	Concentration (ppm)					
	10	50	100	200	250	500
Captan	34.42	43.74	49.88	54.14	55.80	62.65
Ziram	8.39	11.10	15.18	20.99	26.83	41.37
Bavistin	85.46	100.00	100.00	100.00	100.00	100.00
Ridomil-MZ	30.99	37.16	51.30	53.33	56.51	58.25
Vitavax	37.36	41.84	46.26	54.25	62.65	66.15
Bayleton	11.51	13.60	17.14	21.04	27.65	36.51
Indofil M-45	5.20	10.52	12.46	17.65	26.36	37.23
Fytolan	19.27	21.40	24.70	28.01	33.74	40.07
Topsin-M	83.92	86.76	89.30	100.00	100.00	100.00

Table 2

Effect of different fungicides on the growth of C. graminicolum

Name of the fungicides	Radial growth (mm)							
	Concentration (ppm)							
	0	10	50	100	200	250	500	cd at 5%
Captan	70.50	46.23	39.66	35.33	32.33	31.16	26.33	7.12
Ziram	70.50	64.58	62.25	59.58	55.70	51.58	41.33	2.51
Bavistin	70.50	10.25	0.00	0.00	0.00	0.00	0.00	4.25
Ridomil-MZ	70.50	49.00	44.30	34.33	32.90	30.66	29.43	2.20
Vitavax	70.50	44.16	41.00	37.88	32.25	26.33	23.86	2.99
Bayleton	70.50	62.38	60.91	58.41	55.66	51.00	44.75	1.44
Indofil M-45	70.50	66.83	63.08	61.71	58.05	51.91	44.25	3.59
Fytolan	70.50	56.91	55.41	53.08	50.75	46.71	42.25	2.37
Topsin-M	70.50	11.33	9.33	7.50	0.00	0.00	0.00	1.47

reduce germination from 24-40 per cent. At a concentration of 100 ppm and above both systemic fungicides Bavistin (Carbendazim) and Topsin-M (Thiophanate Methyl) did not permit spore germination as there was almost more than 97 per cent inhibition of spore germination. Other fungicides caused inhibition to the levels of 50 to 60 per cent.

In the present study it was observed that Bavistin and Topsin-M were highly effective in inhibiting the spore germination by *C. graminicolum*, while Bayleton (Thizale), Captafal (Heterocyclic compound), Vitavax (~~Oxanthins~~ group), Mancozeb and Thiram (Sulfur based fungicides), and Ridomil M2 were less effective.

Table 3

Effect of fungicides on spore germination

Fungicides	Concentration (ppm)													
	10		50		100		200		250		500		Mean	
	G	I	G	I	G	I	G	I	G	I	G	I	G	I
Mancozeb	79.37	15.77	72.32	24.28	63.96	32.63	59.59	36.26	55.75	40.99	41.51	56.39	62.08	34.38
Ridomil MZ-72	77.80	18.53	67.10	29.50	62.92	33.68	58.22	37.85	56.13	42.29	42.03	57.44	60.70	36.54
Vitavax	74.67	21.14	61.09	35.77	50.13	45.69	45.16	50.13	31.58	67.88	27.41	70.23	48.34	48.47
Bavistin	6.78	95.82	4.43	96.60	1.82	97.38	0.78	97.38	0.00	100.00	1.04	97.38	2.47	97.51
Topsin-M	3.39	95.30	2.61	96.34	1.30	98.17	0.65	100.00	0.00	100.00	0.00	100.00	1.32	98.30
Bayleton	73.89	22.19	56.65	40.99	49.34	46.07	42.03	53.26	30.54	66.57	26.37	72.84	46.47	50.32
Captafal	73.36	22.71	65.01	28.45	52.48	44.12	48.56	48.30	27.41	71.21	25.32	73.89	48.69	48.11
Thiram	75.19	20.88	58.22	34.20	51.43	46.21	47.89	51.71	26.89	67.10	24.54	74.15	47.36	48.95
Control	95.75	0.00	95.75	0.00	95.75	0.00	95.75	0.00	95.75	0.00	95.75	0.00	95.75	0.00
Mean	62.24		53.68		47.68		44.29		36.00		31.55			

S.Em. 1 = 0.7094 C.D. at 5% = 1.983 C.D. at 5% = For fungicides
S.Em. 2 = 0.8191 C.D. at 5% = 2.289 C.D. at 5% = For Concentration
S.Em. 3 = 2.006 C.D. at 5% = 5.608 C.D. at 5% = For Interaction
G = Spore germination (%)
I = Germination inhibition (%)

* Average of four replications.

Table 4

Effect of different antibiotics on spore germination

Antibiotics	Spore germination and inhibition (%)											
	Concentration (ppm)											
	10		50		100		250		500		Mean	
	G	I	G	I	G	I	G	I	G	I	G	I
Tetracycline	87.08	9.16	83.94	11.34	77.92	23.90	71.03	34.72	54.62	41.01	74.91	24.02
Aureofungin	87.79	8.20	78.70	24.25	74.17	30.54	60.47	39.26	24.60	76.96	65.14	35.84
Streptomycin	90.68	4.71	82.89	20.41	77.13	20.06	73.82	24.25	73.47	23.90	79.63	18.66
Dicristicin	93.37	1.97	85.95	9.24	83.24	18.67	75.57	24.60	74.86	24.25	82.59	15.74
Control	95.50	0.00	95.50	0.00	95.50	0.00	95.50	0.00	95.50	0.00	95.50	0.00
Mean	90.88		85.39		81.62		75.27		64.61			

S.Em. 1 = 0.3489 C.D. at 5% = 0.9912 C.D. at 5% = For comparison on between treatment
S.Em. 2 = 0.3489 C.D. at 5% = 0.9912 C.D. at 5% = For comparison between concentration
S.Em. 3 = 0.7803 C.D. at 5% = 2.2165 C.D. at 5% = For interaction
G = Spore germination (%)
I = Germination inhibition (%)

* Average of four replications

Table 5

Effect of different antibiotics on growth of C. graminicolum (dry weight)

Antibiotics	Dry weight of mycelium (mg)					Mean
	Concentration (ppm)					
	10	50	100	250	500	
Tetracycline	89.00	80.33	75.33	63.66	31.33	67.93
Aureofungin	90.00	76.33	59.66	20.33	3.33	49.63
Streptomycin	94.33	86.33	82.66	82.33	73.33	83.79
Dicristicin	93.33	91.00	92.33	86.33	82.33	89.06
Control	98.86	98.86	98.86	98.86	98.86	98.86
Mean	93.10	86.57	81.76	70.26	57.83	

S.Em. 1 = 0.3922 C.D. at 5% = 1.114 C.D. at 5% = For comparison on between treatment
S.Em. 2 = 0.3922 C.D. at 5% = 1.114 C.D. at 5% = For comparison between concentration
S.Em. 3 = 0.8770 C.D. at 5% = 2.491 C.D. at 5% = For interaction
Average of four replications.

Effect of the antibiotics on spore germination : The results obtained in the present investigation revealed that as the concentration of antibiotics increased there was corresponding increase in the levels of inhibition of spore germination. The results are given in Table 4. Lower concentrations were relatively less effective in inhibiting the germination of spores. Minimum concentration of 10 ppm of all the antibiotics invariably resulted in least inhibition of spores germination, while the highest concentration of 500 ppm proved highly effective as it gave maximum inhibition. Among the antibiotics tried, Aureofungin accounted for more than 77 % of inhibition of spore germination when used at 500 ppm and concentration. The antibiotic Tetracycline was found less, effective than Aureofungin as it caused only 41 % inhibition at the same concentration. The other two antibiotics viz., Streptomycin and Dicristicin were inferior as compared to the above two listed antibiotics as they gave only 23 and 24 % inhibition of spore germination at 500 ppm concentration, respectively.

Effect of antibiotics on growth of C. graminicolum (dry weight) : The results revealed that as the concentration of antibiotics increased, there was reduction in dry weight of mycelium. Lower concentrations were relatively less effective in inhibiting the mycelial growth in term of dry weight. Lowest concentration of 10 ppm of all the antibiotics invariably resulted in more dry weight of mycelium, while the highest concentration of 500 ppm proved highly effective as it gave lowest mycelial dry weight. Among the antibiotics tried, Aureofungin was found to be best as it gave least dry weight of mycelium (3.33 mg) at 500 ppm concentration. The results are given in Table 5. The antibiotic Tetracycline was less effective than Aureofungin as it gave the dry weight of mycelium (31.33) at same concentration. The other two antibiotics Streptomycin and Dicristicin were inferior as compared to the above two as they gave 73.33 mg and 82.33 mg dry weight of mycelium was found highest (98.86 mg). It can be concluded that there were significant differences among the five concentrations of antibiotics with respect to dry weight of the mycelium.

Acknowledgements

The authors are grateful to Dr. N.K. Joshi and Mr. Sikandar Ali for their meticulous guidance, constructive criticism and persistent encouragement right from the initiation of the problem to the preparation of this manuscript. Authors are also grateful to Mr. J.N. Gandhi, Mr. Piyush Madhaw, Mr. B.C. Joshi, Dr. Arif Husain and Mr. L.M. Goswami for discussion and valuable suggestions.

SUMMARY

Anthracnose of Poplar caused by *Colletotrichum graminicolum* is a serious disease in Tarai region of Uttar Pradesh. The present investigation were undertaken to study the screening of fungicides and antibiotics against the pathogens under *in-vitro* conditions. Hundred per cent inhibition of *C. graminicolum* was recorded in Bavistin (50 ppm and onward) and Topsin-M in 10 ppm and above. Aureofungin was found highly effective against this fungus in reduction of radial growth as well as spore germination.

कौलेटोट्राइकम ग्रैमिनीकोलुम से पोपलर में होने वाले कालव्रण रोग के प्रति कवकनाशियों प्रतिजीवियों का प्रतिचार

दीपक सिंह, जे०पी० चन्द्र व ए०बी० सिंह

सारांश

कौलेटोट्राइकम ग्रैमिनीकोलुम से पोपलर में होने वाला कालव्रण रोग उत्तर प्रदेश के तराई प्रदेश की एक गम्भीर बीमारी है । प्रस्तुत अन्वेषणों को कांचीय दशाओं में इसके रोगजन पर कवकनाशियों और प्रतिजीवियों के प्रभाव की पड़ताल करने के लिए आरम्भ किया गया है । काचीय दशाओं में बाविस्टिन (50 भाग प्रति दस लाख भाग पानी में मिलाकर अथवा इससे अधिक मात्रा में) तथा टाप्सिन-एम 10 भाग प्रति दस लाख भाग पानी में मिलाकर अथवा इससे अधिक मात्रा में उपयोग करने पर *कै० ग्रैमिनीकोलुम* से शतप्रतिशत रोकथाम होती आलेखित हुई । इस कवक की अरीय भाग में वृद्धि को तथा रोगाणु अंकुरण कम करने में औरियोफंगिन अत्यधिक प्रभावकारी पाया गया ।

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CONFLICT RESOLUTION : A CHALLENGE FOR JOINT FOREST MANAGEMENT IN INDIA

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Introduction

"Nineties will be nanosecond culture. There shall be only two kinds of managers - the quick and the dead" (Peters, 1993). The natural resource manager has to be quick to comprehend the changing forestry scenario and adopt a proactive management approach rather than reacting to ensuing environmental degradation and ecological insecurity gulping mother earth at a fast pace. The strategic shift in forest management in India from traditional forestry management to participatory forest management has ushered an era of change. It has led the natural resource manager to look at the resources with a different angle altogether. The forester is put to more challenging roles of communicator, negotiator, facilitator, conflict resolver, motivator and coordinator apart from providing technical guidance to the developmental and conservation responsibilities. This strategic shift is in favour of people so as to make symbiotic relation of man and nature much more meaningful. Till date, sixteen State Governments in India have adopted the enabling resolutions in favour of Joint Forest Management (JFM). The present shift in forest management practices favour people's involvement, collective decision making, social fencing approach, empowerment of community, sharing of authority, focus on Non-Timber Forest Produce (NTFP), continuous harvest of usufructs. It has been fully realised that people's participation in forestry is a *sine qua non*. The philosophy and concept of JFM is well mature whereas it's systematic development and replication is still in an evolutionary phase. Certain success models like Sukhomajri, Arabari, Harda, Orissa, Karnataka models are the guiding pillars of people's participation. JFM does not provide a push button strategy for development, conservation and protection. JFM is a process-oriented concept rather than product-oriented. It involves understanding the intricate relationship of the people with the availability of forest resources and their dependence on it. In the process of development of JFM, it is realised that certain internal as well as external conflicts exist. The sooner these conflicts are deciphered, understood and resolved better it would be for the institutionalization process of JFM in India.

The pluralism of values surrounding natural resources is the hallmark of the conflicts confronting the present day resource management. Different values, different perceptions, differing objectives (Anon., 1995) and differing interests must be acknowledged while resolving the conflicts. The present day ecological conflicts have their roots in economic compulsions, sociological stresses, technological intensification, changing consumption patterns, scarce land availability and contending resource uses. Making trade-offs between competing goals is thus a necessary skill for the officials. Some of the conflicts relating to natural resource management are mentioned below :

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- Issue of short term livelihood needs and long term ecological conservation.
- Increasing biotic interference and limited carrying capacity of forest area.
- Resource ownership and programme ownership.
- Controls on exploitation and harvesting and increasing the scope of sharing.
- Extent of management by the people.
- Socio-cultural background and collective management ensuring equity and no gender biases.
- Poor or limited market infrastructure/ information and emphasis on NTFP's marketing.
- Economic, political and social plurality and task singularities as collective resource sharing, recycling the benefits and participatory decision making.
- Strong authority of Forest Department and sharing of authority, responsibility, control facilitating empowerment.
- Demands between large users of forest products i.e. big contractors and small operators/forest users of NTFP.
- Demands between forestry and non-forestry uses of land in Reserve Forest areas (Castro, 1991).
- Agriculture vs. Forestry interests.
- Monoculture vs. Bio-diversity and poly-culture.
- Commercial interests vs. Conservation interests.
- Lack of recognition of and local knowledge and cultures.
- Inadequacy of technological inputs vs. integrated developmental models.
- Private sector and Government. pressures on communities.
- Divergent interests competing over same resources i.e. proximate and distant users.

A common property resource is one can be subjected to joint use, meaning not only that several users can derive benefits from using the resource, but also that overuse or misuse can diminish the resource's value to all users (Soroos, 1992). Several conflicts are possible.

Resource Use Conflict

- Interference between similar uses of resource domain exist in village environs. It causes inter- and intra-village rivalries over the use of pastures, water bodies, land area and other natural endowments.
- Interference between dissimilar uses of commons was reported where in the Bakkarwals have the grazing rights over forest land and the village communities retain rights to dry twigs timbers etc. over the same areas. The overlapping rights and conflicting use are to be resolved. Would it involve rationalizing the livestock holding of the Bakkarwals or changes in the use practices of allotted land areas or the interventions combining both the option? (Chatterji and Gulati, 1991). If the changes are to be induced in use practices and patterns, what options exist as alternatives?
- To induce a cultural change or behavioural change in use or consumption patterns without alternatives is a difficult task. Economic circumstances and realities tend to severely limit the options available to the people.

- The poor tribals do not consider Teak plantations as timber resource but as fuelwood resource. Many-a-times a forest product is misvalued what one has to trade.
- The concepts of nutrient recycling, water balances and ecological security though closely related to ecological sustainability are ignored at the cost of quick economic returns.

Structural Conflicts

- Situation of mutually exclusive consumption abounds when the harvesting of a resource by one group precludes it's consumption by the others.
- Conflicts often arise due to organizational design. The duality of control on Van Panchayats in Uttar Pradesh have made them dysfunctional.
- JFM's effectiveness depends on valid communication across subcultural boundaries. Constant dialogue and communication of all the players in vertical as well as horizontal directions are needed to introduce changes. A culture specific communication strategy should be evolved as part of forestry extension.
- In view of JFM, the suggested areas of change relate to personal policies, appraisal formats, disciplinary process and emphasis on sensitive leadership and innovativeness.
- Fears, apprehensions, skepticism in the minds of players spoil the institutionalization process of JFM.
- Forest Department systems involve hierarchy, elitism and corporate structures. The prospect of facelessness through loss of identity, authority and control bothers both staff and managers.
- NGO's involvement led to the alienation of Foresters. The involvement of foresters diminished on account of perception that credit for the enterprise went to NGO (Choudhury, 1993).
- NGOs/State working groups help in conflict resolution, monitoring and evaluation on a continuing basis. Making user more accountable for the consequences of overuse and misuse shall be the prime task. The required coordination amongst various departments is necessary. The lift irrigation system did not work effectively as the pumps could not be energised by Electricity Department or the channels were not maintained by Irrigation Department. NGOs may provide the needed coordination and advocacy work (Anon., 1993).
- Bureaucratic rigidity and administrative bottlenecks continue to challenge those who would like to innovate radically with community organisation, participatory planning, budgetary allocations, new silviculture, value additions to NTFPs and benefit sharing (Campbell, 1996). The problems relate to identification of legitimate representative of stakeholder, difficulties in arranging communications and lack of information sharing (Pendzich *et al.*, 1994).
- There exist three types of community institutions - one emerging out of local initiative, other promoted by local Forest Department and third sponsored by local self government (Sarin, 1996). These three structure have their own problems and in-built conflicts.

Role Conflicts

Conflicts may arise if differences exist in felt needs, expectations, projections, attitude and values of the actors involved in JFM (Rastogi, 1995). Role conflicts occur when people face conflicting set of expectations. Some role conflicts appeared in JFM process are being listed.

Inter-sender conflicts : A village level worker is often subjected to contradictory expectations from different people. In the village setup, group rivalry or village rivalry puts forester/Committee member in a tight spot. In such situation Inter-sender conflicts occur. A person responsible for exploitation also shared the responsibility for conservation.

Intra-sender conflicts : A forester/ Committee members often face Intra-sender conflicts when they are supposed to be the law keeper as well as lenient while dealing with offenders who is also a local person.

Inter-role conflict : Inter-role conflict takes place when a person plays roles which conflict each other. The people play the role of protector as well as offender. When the conflict reaches a limit, one role is left.

Person-role conflicts : When the actor does not fit the role person-role conflict takes place. A role may be too demanding or too difficult, boring, unethical or time consuming. NGOs face this conflict very often.

People's disposition towards an actor or programme may play havoc with the JFM process.

Interest or Need Conflicts

- Conflict of interests occur when one use of commons causes collateral damage to the territory or the rights of others. The economic and environmental security is jeopardized by resources scantiness and additional pressure on the left overs.
- Partial closing of the planted area was taken to mean by some interests that rest of the area was free for grazing (Choudhury, 1993).
- Opposing interests of loggers, rubber tappers and ranchers in Brazil have led to armed clashes. Loggers/shifting cultivators tend to encroach upon forest lands. It is necessary to accommodate the personal profits and community benefits both for sustaining the enthusiasm and motivation of the people. In the village environs the needs for landlord, landless, herder/grazier, daily wage labourer, rural artisan are diverse. To accommodate the concern of all sections is the challenging task in JFM.
- The task of reaching agreement to implement any one of them raises additional conflicts of interests that must first be resolved.
- Due to different need profile and varying degree of commitment to addressing the problems that occur when the resource domain is handled collectively, Interest/Goal conflict exists. Conflicts exist on approach even if the goal are agreed to.

Legal Conflicts

The JFM notifications have not taken note of the potential legal conflict arising due to either customary rights or the legal rights under the Forest Acts over the forest resources extended to the people. Further creating a new group such as Forest Protection Committee (FPC) and giving them special or over-riding rights is legally problematic and often *ultra vires* (Singh, 1991). The non-statutory FPCs have no legal backup for credit mobilisation, undertaking market operations, creating entrepreneurial base in rural areas and integrating the developmental programmes with other governmental departments. The work domain of FPCs many times does overlap with the local self governments i.e. Panchayats. The Forest Act has no provisions to empower the Cooperative/Panchayat/FPC to impose punitive fines on the offenders (Raju, 1993). It calls for harmonisation of JFM rules and regulations with the existing set of legal instruments structures, use rights and the 'right-regimes'. The rights, responsibilities, powers to the FPCs shall be clearly spelt out and legally formalised. The uncertainty about the sharing of usufructs may lead to irresponsible behaviour on part of actors in the process. It is imperative to properly demarcate and allocate the forest areas to the FPCs.

Cultural Conflicts

Village people have patterns of culture which are well integrated with forest cycle; from collection of seeds to harvesting of crops. Forestry operations and societal rituals are closely connected. This interlocking deserves to be appreciated and utilised in planning and development process of JFM. Some of the cultural conflicts which surface in the process are mentioned below :

- The degree of dependence and expectation of nurturance from the Forest Department is high. People see government officials as 'Mai-Bap' or an authority in absolute terms.
- In a village, class differences based on land ownership, income, caste, occupation are pronounced. These differences have assigned cultural superiority/inferiority. Rural elites monopolise the credit and marketing facilities. Elites have the knowledge, time and resources to pursue their goals. Caste conflicts surface when the lower castes defy their 'traditional obligations' towards the upper castes. The caste structures have reinforced the traditionally ordained relationships i.e. landlord and tenant, master and servant, creditor and debtor, patron and client (Srinivas, 1993). JFM faces conflicts as it facilitates cultural mobility having latent potential for social change.
- Paid jobs, migration to towns, television, telephone, banks, schools have diluted the ideological rigidities amongst caste groups and heightened the status of lower castes. Socio-cultural changes have followed technological changes in the rural environs. The upper castes have found alternative bases of social status through westernisation. Demographically generated changes, pressures, innovations and conflicts lead to lasting changes in local environs. This ensuing transformation in rural areas has tended to alienate the younger generation from thinking about the protection and development of proximate forest areas.
- The gender bias is built into the cultural ethos. The conservative family structure, purdah system, traditional work allocation give specific role to women. This age old ethos will not evaporate overnight. Similarly the poor do not feel empowered as they feel that equity in profit sharing does not exist.
- In general the rural communities have no traditions of voluntarism in conserving and developing forest areas.

Heterogeneity persists in relation to values and beliefs because of differences in experience, age, education, position and status. The resistance to new processes arises due to unrealistic expectations, misperceptions, poor communication and lack of understanding between the actors.

Proactive conflict resolution is an in-built component for any participatory management practice. The resource competition is all pervasive and exists in it's acutest form. The conflict is also to be adjudged from the view of intensity of stakes and their solvability. Good negotiators react only after making both decisions otherwise they increase the risk of acting incompatibly with either the solvability or intensity of conflict. Power imbalances undermine efforts at reaching a lasting solution and solvability. Conflicts are dynamic, positions and alliances change, community negotiators need to detect and take advantage of the "cracks" and vulnerabilities that present themselves. Legitimisation of the weaker party's perspective and the validation of it's position through the negotiation process can result in community empowerment and transformation.

The conflict resolution mechanism poses the biggest challenge to the natural resource managers. The challenge lies with creation of social institutions with objectives of social equity and ecological sustainability which match the resource endowment and management requirements. The concept of Joint Forest Management in India ranges from mere window dressing where it is a euphemism for participatory self-government, to real devolution of management decision making to local user groups (Anderson, 1995). Unattended conflicts are the reason for differential performance of JFM in India. Gaining expertise in conflict management includes learning about specific advantages and disadvantages of various strategies, and assessing which is the best in addressing a particular conflict situation. The basic problem in a negotiation lies not in conflicting positions, but in the conflict between each side's needs, desires, concerns and fears (Fisher *et al.*, 1991).

People who are skilled in negotiation, mediation and conciliation are seen as having qualities of leadership than the brute who grows in power and then uses that power to grow more. The empowerment of people through JFM ultimately deals with diffusion, fractionalisation and thinly spreading of power among more people than concentrating in traditional structures (Rastogi, 1993). JFM represents a process of decentralised empowerment benifitting some of India's most disadvantaged groups (Poffenberger and Singh, 1991). Negotiations play a major role in empowerment process where autonomy and democratic processes at community levels are facilitated.

Quality and Pace of negotiations

If there exist resource conflicts regarding land, labour, money, time and space, these may be negotiated quickly and a consensus solution may be evolved. In case of pathway conflict wherein each party supports achievement of an accepted goal based on concern for it's own convenience or position, the consensus decisions though prolonged yet emerge as an effective solution. The value conflict is connected to a commitment or belief which arouses responses that ignore facts. It has endless tube of irrational, unrealistic demands chain-linked by emotions. The effective solutions rarely emerge. However, the longer a conflict exists, the more likely its importance will escalate. The quality and pace of negotiation depends on the type of conflicts.

Conflicts are allowed to get worse because the community no longer has the functional system for addressing them (Pendzich, 1993). Despite several internal as well as external conflicts, there is the need for integrated philosophical foundation to resource management. The challenge lies in the pace of internalisation.

The World Commission on Forests and Sustainable Development shall look into the intricate relationship of ecology, economy and culture. The related conflicts shall be identified. A national level task force shall do the trouble shooting. The national task force shall form ecological region specific international working groups so as to learn from other's experience. A national level apex body shall help in evolving conflict free and congenial environment for JFM to flourish.

The usufruct-based trees provide the technological solutions and help in resolving the conflicts favouring the poor as well as the rich (Saxena, 1991). The focused training and skill building would greatly enhance the community's as well as forester's ability to resolve both internal and external conflicts. Analysis of roles of different actors, their interests, positions, their alternative solution and likely strategies (Pendzich, 1993) are necessary for resolving the conflicts. Proactive handling of conflicts shall prepare the forest communities to observe the benefits of Joint Forest Management on progressively increasing scale.

SUMMARY

The present day ecological conflicts have their roots in economic compulsions, sociological stresses, technological intensification, changing consumption patterns, scarce land availability and contending resource users. Making trade-offs between competing goals is thus a necessary skill for the officials. Inventory of conflicts relate to resource use, structures, roles, interests, socio-legal and cultural attributes. However to decipher, understand and resolve the conflicts through effective communication, negotiation, mediation and conciliation poses a challenge before the natural resource manager. The paper stresses that the conflict resolution mechanisms are to be evolved, institutions developed and structures harmonised with the needs of Joint Forest Management (JFM) in India.

टकरावों को समाप्त करना - भारत में संयुक्त वन प्रबन्ध की एक चुनौती

आलिन्द रस्तोगी

सारांश

आज के पारिस्थिकीय टकरावों की जडें आर्थिक मजबूरियों, समाज वैज्ञानिक दबावों, प्रौद्योगिकी चण्डताओं, बदलती हुई उपभोग सज्जाओं, जमीन की कम उपलभ्यता और प्रतिस्पर्धी भूमि उपयोगकर्ताओं में छिपी हुई हैं । परस्पर प्रतिस्पर्धा करते लक्ष्यों में व्यापार की संगति बैठा पाना इसलिए सरकारी कर्मचारियों के लिए एक अनिवार्य कौशल ही बन गया है । टकरावों की सूची में आते विषय,, संसाधनों के उपयोग, अधोसंरचनाओं, भूमिकाओं, हितों, समाज - विधिक और सांस्कृतिक तत्वों से संबंधित हैं । इसके अतिरिक्त प्रभावकारी समझ-बूझ वार्ता मध्यस्थता और मेल-मिलाप द्वारा इन टकरावों का पता लगाना, इन्हें समझना और निबटाना भी प्राकृतिक संसाधनों के प्रबन्धकर्ता के सामने चुनौती बनकर खडे होते हैं । इस अभिपत्र में इस बात पर बल दिया गया है कि भारत में इन टकरावों को निबटाने की यन्त्र क्रिया विकसित करने, संस्थाओं का विकास और अधोसंरचनाओं को संयुक्त वन प्रबन्ध की आवश्यकताओं के साथ समरस बनाने की बहुत आवश्यकता है ।

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PHENOLOGY OF ALPINE PLANTS IN THE VALLEY OF FLOWERS NATIONAL PARK AND HEMKUND, WESTERN HIMALAYA

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Introduction

Plant phenology is one of the most prominent features of vegetation that reflects the ecosystem's properties. The timing of different plant phenophases affects not only the plants, but also animals that depend on plant resources. It impinges on plant-plant interactions such as competition for resources or pollinator and disperser activity, which can limit the range of plant species. In addition, the timing of seed production can profoundly influence population dynamics (Newstrom and Frankie, 1994).

In alpine meadows, the growing season is limited to a few months, within which plants complete their life cycle. The growing season decreases with increase in altitudes (Rawat and Rodgers, 1988) and is only a few weeks near the snow line (Rawat and Pangtey, 1987). Early attempts to document the phenology of alpine plants in the Himalaya include Ram *et al.* (1988), Ram and Arya (1991), Singh (1991) and Negi *et al.* (1992). In this paper, besides general phenology, the trend in phenology along an altitudinal gradient have been examined. Attempts were also made to find out how different growth forms phase their growth cycle within the short growing season of harsh climate.

Study Area

The study was carried out in the Valley of Flowers National Park (VOF) and Hemkund located in the Chamoli District of Garhwal Himalaya (30° 41'- 30° 48' N and 79° 33'-79° 46' E). This area forms the upper catchment of river Bhyundar Ganga which drains into river Alaknanda, a major tributary of Ganges. The VOF is nestled among the snow clad summits viz., Nilgiri Parvat (6407 m asl), Gauri Parvat (6590 m asl), Rataban (5400 m asl), Sapta Sringa (5025 m asl), and Kunt Khal (5855 m asl). The altitude of the study area ranges between 3000 m asl to 6590 m asl with the topography of undulating, flat plateaus and steep slopes. Frank Smythe was the first European who reached this Valley in 1931 and subsequently published a book *The Valley of Flowers* (Smythe, 1938). The major portion of the VOF is under alpine pastures which remain under snow between November to April. About 520 plant species have been reported from the VOF (Wadhwa *et al.*, 1987; Kala, 1998). The total area of the VOF is 87.5 km^2, of which 63.58 km^2 is under perpetual snow. Forest (sub-alpine) constitutes only about 5.29 km^2 area while the alpine meadow covers 18.63 km^2 area (Kala, 1998). With the upgraded status of the VOF from the Reserve Forest of the National Park it was ensured that along with alpine flora the resident fauna is also protected. In accordance with the provisions contained in the Wildlife (Protection) Act 1972, domestic livestock grazing was stopped within the National Park.

The climate of the study area is moist temperate and alpine type, with short cool summers and long severe winters. Mean monthly minimum and maximum temperature recorded in the area is given in Fig. 2. The total rainfall during summer (May-October) was estimated as 1075 mm, of which highest was in August (383.5 mm). Relative humidity varied between 80-100%. Snowfall begins in November and continues till April, but on the high peaks it keeps on falling throughout the season. Cloud and fog formation are regular features and the period of clear sky is limited to only a few morning hours each day.

Methods

Two transects, one from Ghangaria (3000 m asl) to the lower parts of Valley of Flowers National Park (VOF, 3500 m asl), and the other from 3200 m asl near Ghangaria to Hemkund (4100 m asl), were monitored for 2 seasons (May to October 1993 and 1994). The former transect was almost parallel to the tree line while the latter was along an altitudinal gradient from sub-alpine fir-birch forest to the alpine zone. The length of transects for VOF and Hemkund were 3 and 6 km respectively. VOF was selected for detailed phenological study, whereas changes in phenology with increasing altitudes was monitored along Hemkund transect. A total of 10 fixed square plots of 10 m^2 were monitored from May to October 1993 and 1994 at 300 m intervals. Species content of the plots were almost similar. To study the effect of altitudinal change on phenology, 10 plots of 10 m^2 were marked at intervals of 100 m altitude on the way to Hemkund, between 3200 and 4100 m. Phenological observations were made once every month, from May to October 1993 and 1994.

Data was collected on the following phenophases: vegetative phase (phase from growth initiation to initiation of flowering), flowering, fruiting, and senescence. The onset of senescence was recognizable due to a rather abrupt change in the colour of leaves which preceded the death of the shoots. If a given phenophase was observed in at least 5% of the individuals of a species in the plots, the phenophase was considered to have started. When less than 5% of individuals of that species remained in a given phenophase, the phenophase was regarded to have completed for the species. Since the individuals of a species showed a strong synchronization for various activities, it was easy to identify the above stages.

Besides general monitoring of phenology, the sample species were categorized into the following growth forms: (1) shrubs and undershrubs, (2) tall forbs (>30 cm height), (3) short forbs (>30 cm height), (4) spreading and cushion-forming forbs, and (5) grass-like plants including sedges. Further, on the basis of the length of growth cycle, three categories were recognized : (1) short growth-cycle species, completing growth-cycle within 2 months, (2) intermediate growth cycle species, completing growth cycle in 2 to 4 months, and (3) long growth cycle species, completing growth cycle in more than 4 months. Phenological data were analyzed for all species occurring within sample plots by aggregating species in different phenophases (vegetative, flowering, fruiting, and senescence) on a monthly

Table 1

Proportional distribution of various plant growth forms in different categories of growth cycle in the Valley of Flowers

Growth forms	Short growth cycle (>2 months)	Intermediate growth cycle (2-4 months)	Long growth cycle (>4 months)	Total species (%)
Shrubs and under shrubs	0	13 (100)	0	13 (14)
Tall forbs	0	16 (52)	15 (48)	31 (33)
Short forbs	5 (24)	11 (52)	5 (24)	21 (22)
Cushion and spreading forbs	4 (14)	10 (36)	14 (50)	28 (29)
Grasses and sedges	0	2 (100)	0	2 (2)
Number of species	9 (9)	52 (55)	34 (36)	95

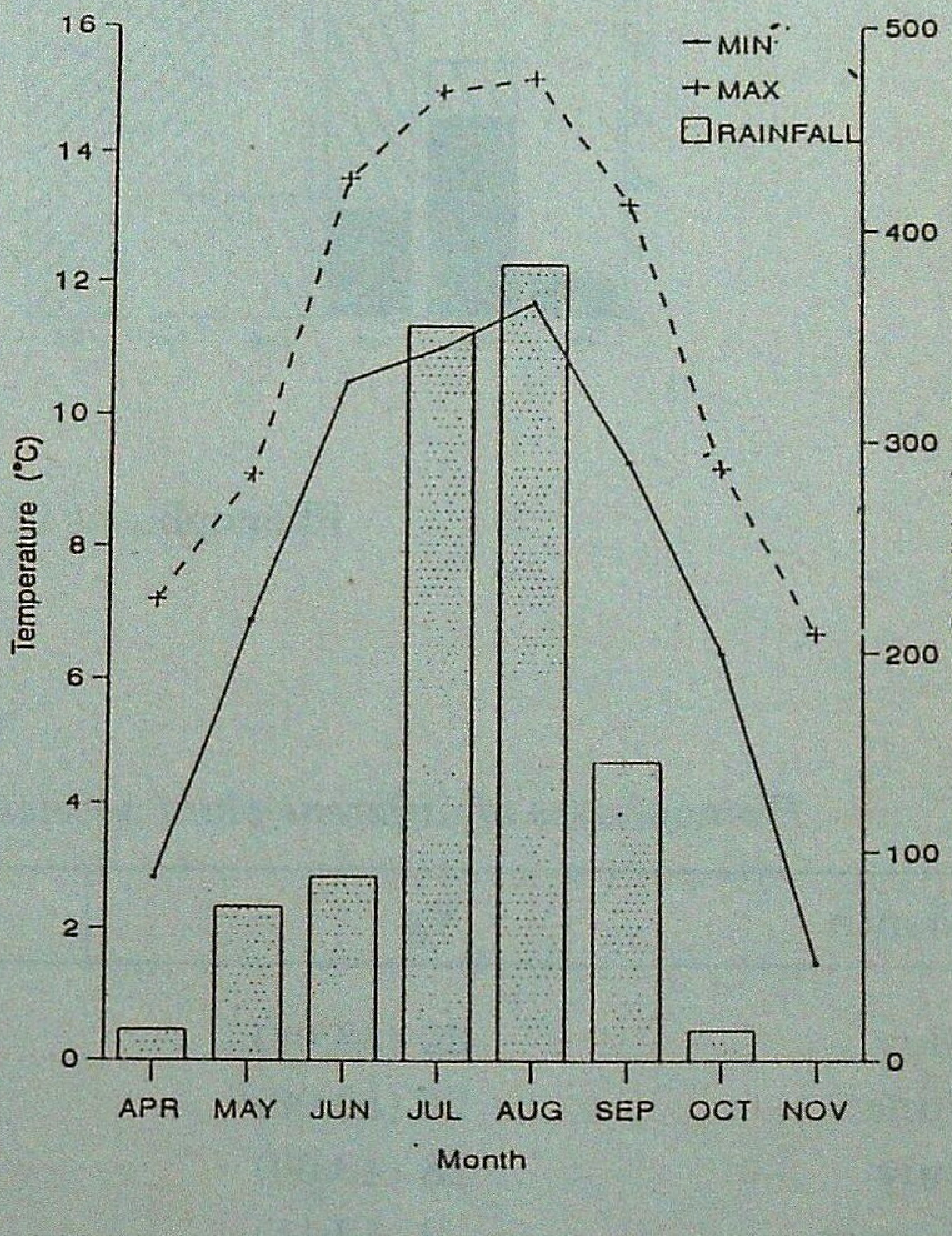
Values in parentheses are percentages.

bases. This was done to determine the proportion of different phenophases in relation to time within the National Park.

Results

A total of 95 flowering plant species occurred within sample plots along the VOF transect, of which 84% were forbs (33% tall forbs, 22% short forbs, and 29% cushion and spreading forbs), 14% evergreen shrubs and under shrubs, and the remaining 2% were grasses and sedges. About 9% completed their growth cycle (from the initiation of growth to the beginning of senescence) within 2 months, 55% of species with 2 to 4 months, and in 36% species the growth cycle extended to more than 4 months (Table 1). The prominent vegetative phase peaked earlier in the cushion forming forbs (in June) than in other forms. Flowering peaked in July, fruiting in August and senescence in September and October in the cushion forming forbs, earlier than in other forms (Fig. 2).

Fig. 1

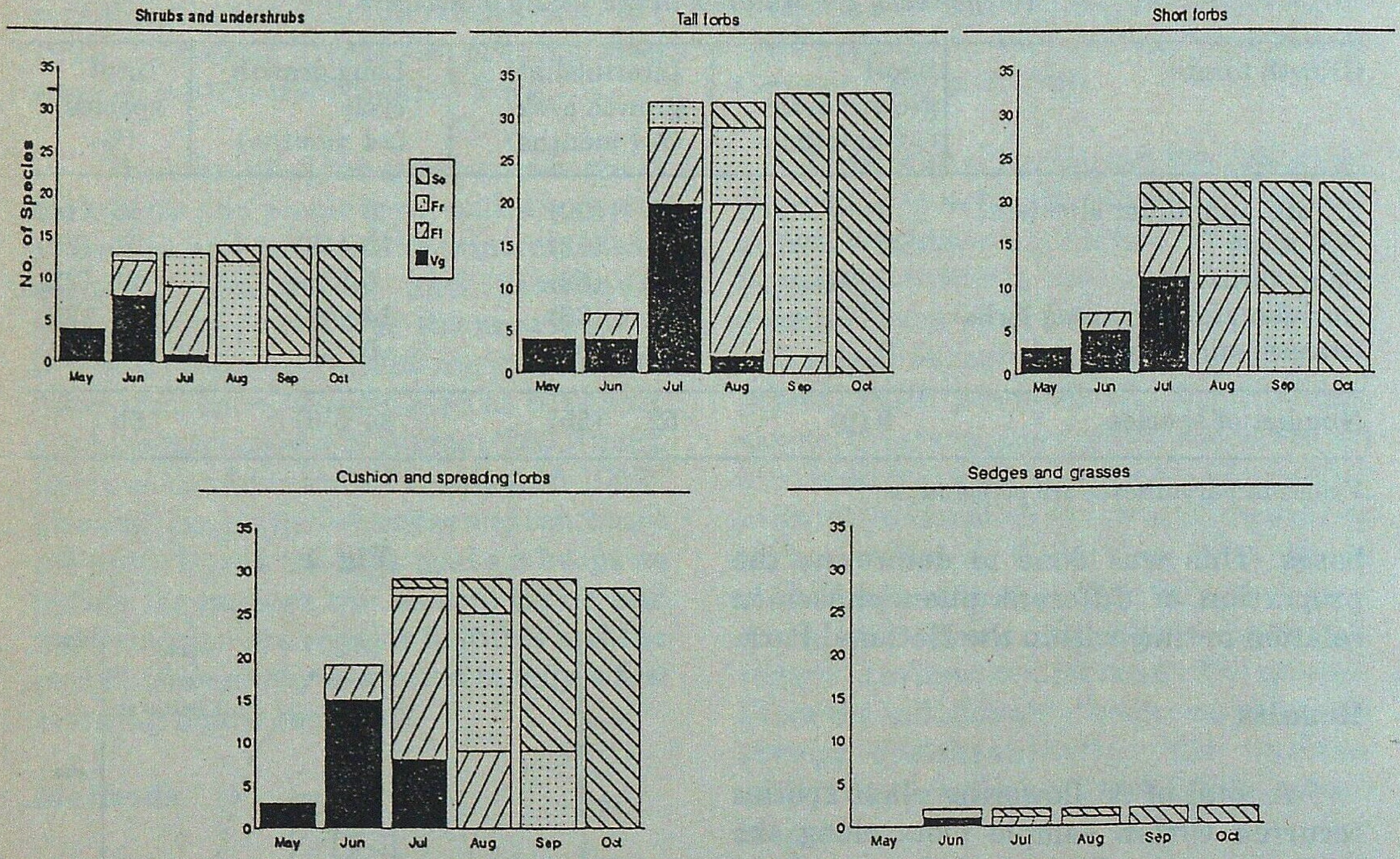


min = minimum temperature; max = maximum temperature

Climatological data of Valley of Flowers

In 34% of the species, growth initiation and vegetative phase began with a rise in temperature and the melting of snow in the last week of May. However, the vegetative phase peaked in June (about 25 to 35 days

Fig. 2



Phenophases in different growth forms

Table 2

Phenophases of different plant species in different months in the Valley of Flowers

Month	Vg	Fl	Fr	Sc
May	32 (33.68)	4 (4.21)	0 0	
June	76 (80.00)	17 (17.89)	2 (2.11)	0
July	38 (40.00)	42 (44.21)	10 (10.53)	5 (5.26)
August	2 (2.11)	36 (37.89)	42 (44.21)	15 (15.79)
September	0	2 (2.11)	35 (36.84)	58 (61.05)
October	0	0 0	95 (100.00)	

Vg: Vegetative; Fl: Flowering; Fr: Fruiting and Sc: Senescence
Values in parentheses are percentages.

after snow melts) when 80% species were in vegetative phase. There was no significant correlation between per cent phenophases and rainfall (Pearson's r = 0.4068) and per cent phenophases and minimum temperature (r = 0.5047). The only significant positive correlation was between the per cent phenophases and maximum temperature (r = 0.5440).

Some of the species such as *Primula denticulata, Caltha palustris, Gentiana capitata* and *Gagea elegans* begin to flower as soon as snow melts. However, flowering increased from June, and by late July about 44% of the species came into flower. July and August were the best months for flowering, with 82% species flowering during these two months. In a few species fruiting began in June, and peaked in August, after which it declined sharply, and by October, none of the species bore fruits (Table 2). Senescence proceeded gradually from July to September, thereafter it was sudden and extensive, manifested by brownish colour of plants.

Outside the VOF, along an altitudinal gradient from the sub-alpine fir-birch forests of Ghangaria (3200 m) to alpine meadows (4100 m) of Hemkund, phenology varied with the altitude (Fig. 1). Based on the pattern of plant phenology (Fig. 1) the area could be stratified into three altitudinal strata: 3200-3400 m, 3400-3800 m and 3800-4100 m. The growing season was longest at lower altitudes and decreased with increasing altitude from sub-alpine forest to alpine meadows.

Discussion

Most alpine plants of higher altitudes complete their growth cycle within 2 to 4 months (Bliss, 1966; Billings and Mooney, 1968). In the alpine meadows of the Himalaya, the peaks of the various phenophases succeed one another, within a short period of about four months from May to September (Singh, 1991). Contrary to this in lower elevations of the Central Himalaya, even deciduous species of forests exhibit a growth period of 6 to 10 months and the dominant species take the whole year to complete their growth cycle (Negi, 1989). Singh (1991) pointed out that initiation of the growing season in alpine meadows depends upon the amount of snowfall in the preceding winter, and the start of snow melt during spring. The growth period, defined as the period when plants are metabolically active (Billings, 1973), was about 120 days in the VOF, which is intermediate between the lengths reported for the equatorial alpine land (365 days) and the polar alpine region at 75° N Lat. (71 days) (Billings, 1973).

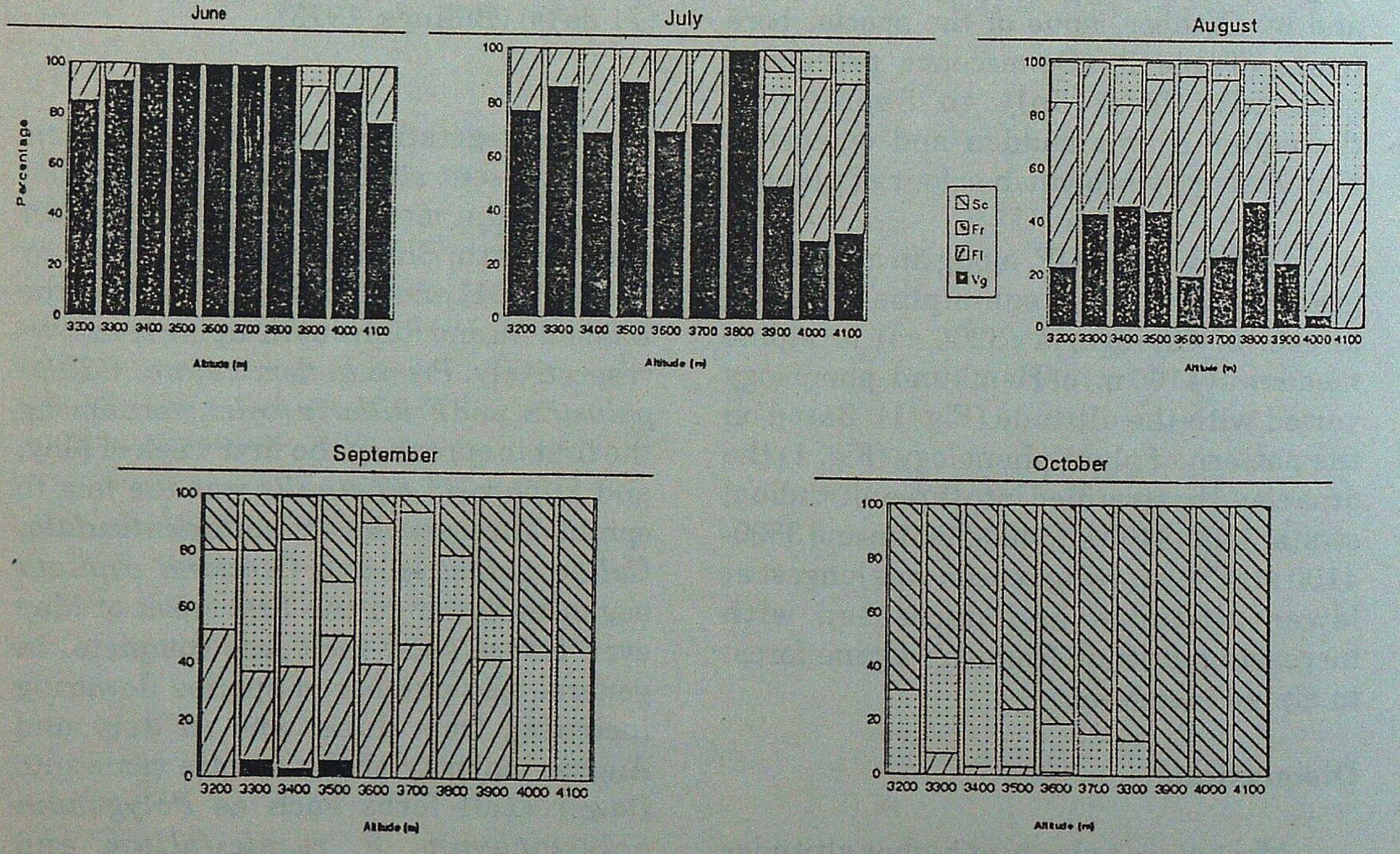
The vegetative phase peaked in June in the present study area indicating that this was the most favourable period for plant growth. Similar trends observed by Singh (1991) and Ram *et al.* (1988) in the Baideni Ali and Rudranath alpine meadows respectively. *Primula denticulata, Caltha palustris*, and *Fritillaria roylei*, were among the first to sprout, in the first week of May, and *Euphrasia officinalis* was the last to sprout. Three species, *Primula denticulata, Caltha palustris*, and *Gentiana capitata* began to flower in the first week of May even before snow melt was complete. In general, the number of species flowering increased from June, and in July and August majority of the species came into flower. Tall forbs such as *Polygonum polystachyum, P. rumicifolium* and *Selinum candollii* flowered during the second half of August.

Table 3

Growth form spectrum for the study site and comparison with other alpine spectra (% of species)

Growth forms	Valley of Flowers	Baideni Ali (Singh, 1991)	Rudranath (Ram *et al.*, 1988)	Bhaderwah Mountains Jammu (Kaul and Sarin, 1971)	Old Man Range of southern New Zealand (Billings and Mark, 1961)	
					Hummock and strip site	Solifluction terraces
Shrub and under shrubs	14	6	3	14	13	0
Tall forbs	33	16	17	15	0	0
Short forbs	22	24	36	28	20	21
Cushion and spreading forbs	29	40	27	37	47	58
Grasses and sedges	2	14	17	6	20	21

Fig. 3



Plant phenophases at different altitudes during different months outside Valley of Flowers

In the cushion and spreading forbs all the phenophases peaked earlier than in tall and short forbs (Fig 2). Similar observations were made by Ram *et al.* (1988) for some selected taxa in the Rudranath alpine meadows of Garhwal Himalaya. Such a temporal variation in growth initiation and completion of life cycle, between cushion forming forbs and tall forbs, may enable the cushion forming forbs to escape competition with larger forms, for resources such as light and nutrients.

There was a tendency for shorter forms in the alpine meadows of VOF to attain peak growth earlier than taller forms (Fig. 2). However, as the season progressed into the late snow-free period, all species tended to complete their growth cycle in the remaining short time available to them. Consequently, in all growth forms, flowering and fruiting peaks occurred over a relatively short period of time. Compared to this, in the vegetation of lower elevations these phenophases are spread over most of the year (Ralhan *et al.*, 1985). Thus, it appears than, in the unfavourable environment of the high elevations, the primary strategy of plants is to complete their growth cycle rapidly, ensuring survival of the species. Interestingly, the peak for flowering during this study occurred during the wet period of the year, in contrast to the observations made by Ralhan *et al.* (1985) on trees and shrubs of the lower elevations, which showed peak flowering during the dry summer season.

The percentage of tall forbs in the VOF was higher (33%) than in any other comparable site (Table 3). This may be due to geomorphological variations in different sites, as the main valley in the VOF is flat and saucer shaped, and the gentle slopes rise continuously changing into steep rugged mountains which aid in soil run-off, carrying soil nutrients along with rain water of the main valley. Hence, the valley area of the VOF is nutrient-rich with deep soil. The other comparable sites of Garhwal Himalaya such as Baideni Ali and Rudranath alpine meadows are on slopes, resulting in poorer soil nutrients due to run-off. The complete absence of tall forbs in Old Man Range of southern New Zealand and differences in presence of cushion and spreading forbs in Himalaya and Old Man Range of southern New Zealand (Table 3) may be because of latitudinal differences in these two mountain ranges. The percentage of cushion and spreading forbs was more or less similar across meadows of the western Himalaya because of climatic and geographical similarities.

Outside the VOF, along an altitudinal gradient, vegetative phase continued for a longer period in sub-alpine forests than in alpine meadows. Plants sprouted earlier in sub-alpine forests, and late at the snow line, whereas die-off began from snow line, down to sub-alpine forests. Rawat and Pangtey (1987) made similar observations for the snow line vegetation of the Central Himalaya, and pointed out that plants adjacent to the tree line (3200 m) have a 20 week season, and which is gradually shortened to 4-6 week towards the snow line (>5000 m). At the higher altitudes not only is the melting of snow much delayed, but the sprouting of the plants and the subsequent life cycle also tend to become quite brief (Rawat and Pangtey, 1987; Rawat and Rodgers, 1988).

The initiation of growth in plants and changes in phenology are governed by various environmental factors. Among them, the influence of temperature and moisture in plant growth has been well documented by several workers (Walter, 1973; Dewald and Steiner, 1986). In the present study site, although rainfall, and minimum temperature also influence the phenology of plant species, maximum temperature is more responsible for the change in phenology, as it is significantly correlated (r = 0.54; P-0.01) with the proportion of phenophases over the months.

Appendix 1

List of species by growth forms and growth cycle

Shrubs and undershrubs

Intermediate growth cycle :
Aster diplostephioides (DC.) Cl.
Berberis jeschaeana Lindl. Schneid.
Gaultheria trichophylla Royle
Jasminum humile L.
Juniperus communis L.
Lonicera myrtillus Hook.f. ex Thoms.
Rhododendron anthopogon Wall. ex D.Don
R. campanulatum D.Don
Ribes glaciale Wall.
Rosa macrophylla Lindl.
Rubus foliolosus D.Don
Salix denticulata Anders.
Skimmia laureola (DC.) Sieb. & Zucc. ex Walp.

Tall forbs

Intermediate growth cycle :
Allium humile Kunth.
Anemone polyanthes D.Don
Arisaema intermedium Blume
A. jacquenmontii Blume
Astragalus chlorostachys Lindl.
Cremanthodium arnicoides Good
Hackelia uncinata (Royle ex Benth.) Fischer
Chaerophyllum reflexum Lindl.
Ligularia amplexicaulis DC.
Nepeta govaniana (Benth.) Benth.
Polemonium coeruleum L.
Polygonatum verticillatum (L.) All.
Rheium australe D.Don
Rumex acetosa L.
Saussurea auriculata (DC.) Sch.-Bip.
Strobilanthes atropurpureus Nees
Long growth cycle :
Anemone rivularis Buch.-Ham. ex DC.
Angelica arch-angelica L.
Eritricum rupestre (Pall.) Bunge
Impatiens sulcata Wall.
Inula grandiflora Willd.
Moringa longifolia Wall. ex DC.
Polygonum polystachyum Wall. ex Meissn.
P. rumicifolium Royle ex Beb.
Rumex nepalensis Spr.
Selinum candollii DC.
S. vagenatum (Edgew.) Cl.
Senecio laetus Edgew.
Synotis kunthiana (Wall. ex DC.) Jeffrey & Chen
Thalictrum cultratum Wall.
Urtica dioica L.

Short forbs

Short growth cycle :
Caltha palustris L.
Lilium oxypetala (Royle) Wils.
Euphrasia officinalis L.
Fritillaria roylei Hook.
Silene gonosperma (Rupr.) Bocquet
Intermediate growth cycle :
Ajuga brachystemon Maxim.
Arabidopsis himalaica (Edgew.) Schultz.
Bupleurum dalhousieanum (Cl.) K. Pol.
Corydalis cashemiriana Royle
C. govaniana Wall.
Cyanoglossum glochidiatum Wall. ex Benth.
Epilobium laxum Royle
Meconopsis aculeata Royle
Parnassia nubigena Wall. ex Royle
Saxifraga diversifolia Wall. ex Seringe.
Sedum crenulatum Hook. f. & Thoms.
Long growth cycle :
Anaphalis royleana DC.
A. triplinervis Cl.
Origanum vulgare L.
Phlomis bracteosa Royle ex Benth.
Stachys melissaefolia Benth.

(Contd...)

Cushion forming and spreading forbs
Short growth cycle :
Gagea elegans Wall. ex D.Don
Gentiana capitata Buch.-Ham. ex D.Don
Primula denticulata Sm.
Sagina saginoides (L.) Karsten
Intermediate growth cycle :
Androsace sarmentosa Wall.
Cerastium cerastoides (L.) Britton
Cicerbita violoides Wall.
Codonopsis rotundifolia Benth.
Fragaria nubicola Lindl. Ex Lacaita
Galium aparine L.
G. odoratum (L.) Scop
Helenia elliptica D.Don
Iris kumaonensis D.Don ex Royle
Thymus linearis Benth.
Long growth cycle :
Polygonum affine D.Don
Clematis montana Buch.-Ha. ex DC.
Cyananthus lobatus Wall. ex Benth.
Geranium wallichianum D.Don ex Sweet
Parochetus communis Buch.-Ham. ex D.Don
Plantago erosa Wall.
Potentilla atrosanguinea Lodd.
Prunella vulgaris L.
Ranunculus hirtellus Royle ex D.Don
Sibbaldia parviflora Willd.
Trachydium roylei Lindl.
Trigonella emodi Benth.
Viola biflora L.
V. canesence Wall.

Grasses and sedges
Intermediate growth cycle :
Carex nivalis Boott.
Poa alpina L.

Acknowledgements

The authors thank Dr. G.S. Rawat, Scientist SF, Wildlife Institute of India (WII) for valuable suggestions and Director, WII, for encouragement to undertake this study. Thanka are also due to Shri V.K. Uniyal and Dr. Nima Manjrekar, for their comments and fruitful discussions.

SUMMARY

Phenology of alpine plants was studied in the sub-alpine and alpine zone of the Valley of Flowers National Park and Hemkund, located in the Western Himalayas. Transects were laid in both the areas and monitored for phenology at every 30 days interval. A total of 95 flowering plant species were found on the transects, of which 84% were forbs, 14% were evergreen shrubs and undershrubs, and remaining 2% were grasses and sedges. The vegetative phase peaked in June and from the same month flowering phase also increased in the valley. July and August were the best months for flowering. The prominent vegetative phase peaked earlier (in June) in the cushion forming forbs than in other forms. The growing season was longest at lower altitudes and decreased with increasing altitude from sub-alpine forest to alpine meadows.

फूलों की घाटी राष्ट्रीय उपवन और हेमकुण्ड, पश्चिमी हिमालय के आल्पीय पेड़-पौधों की ऋतुजैविकी

चन्द्र प्रकाश काला

सारांश

पश्चिमी हिमालय प्रदेश में स्थित फूलों की घाटी राष्ट्रीय उपवन और हेमकुण्ड के उपाल्पीय और आल्पीय क्षेत्रों के आल्पीय पेड़-पौधों की ऋतुजैविकी का अध्ययन किया गया। दोनों क्षेत्रों में अनुच्छेद बनाए गए और प्रत्येक में 30-30 दिन का अन्तराल देकर वहाँ के पेड़-पौधों की ऋतुजैविकी की पड़ताल की जाती रही। अनुच्छेदों से कुल मिलाकर 95 पुष्पीय पादप मिले जिनमें से 84% शाशक (forbs), 14% सदाहरित क्षुप और अनुक्षुप थे और बाकी के 2% घास और वलीक (sedge) थे। प्रवर्धन का शिखरकाल जून में रहा और उसी महीने से घाटी में पुष्पन काल की वृद्धि हुई। पुष्पन के लिए जुलाई और अगस्त श्रेष्ठ महीने रहे। अधिरोही प्रावस्था का शिखरकाल अन्य रूपों की अपेक्षा गद्दा बनते शाककों में पहले (जून में) आया। वर्धन काल कम ऊंचाइयों पर सबसे लम्बा चला और उपाल्पीय से आल्पीय घास क्षेत्रों में ऊंचाई बढ़ने के साथ-साथ कम होता चला गया।

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INDIAN RATTAN DISTRIBUTION - AN UPDATE

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Introduction

Rattans, the spiny climbing palms with about 600 species in 13 genera, are distributed in tropical and sub-tropical Asia and equatorial Africa. In India there are about 60 species of Rattans under 4 genera, Calamus, Daemonorops, Korthalsia and Plectocomia distributed in the Western Ghats of Peninsular India, sub-Himalayan hills and valleys of Eastern and North-Eastern India and Andaman & Nicobar islands. The Rattans comprise more than fifty per cent of the total palm taxa found in India (Basu, 1985).

A comprehensive account of the Asian Rattans was first given by Beccari (1908, 1911, 1918) in which 37 species and 5 varieties were from India. Out of these, 20 species and 4 varieties were reported from N.E. India, 12 species and one variety were from South India and 13 species were from Andaman & Nicobar islands. After this work, Rattans in India have been studied by very few taxonomists (Blatter, 1926; Griffith, 1844-1845; Basu, 1992).

Most of the taxonomic studies in Indian Rattans have by and large, followed Beccari and are based on herbarium collections and field notes available in the various Indian herbaria and some field studies. The over-reliance on herbarium has brought innumerable problems in Rattan taxonomy (Renuka and Vijayakumaran, 1994 a,b). Realising the need for actual field work to straighten out Rattan taxonomy in India, a taxonomic survey was conducted throughout the country (Renuka, 1992, 1995). The distribution data of each species was gathered along with other aspects. The present distribution, the change in the pattern of distribution in the past 20 years and the reasons behind it are analysed in detail in this paper.

Rattans of Peninsular India

21 species have been reported so far from Peninsular India (Renuka, 1992; Renuka *et al.*, 1997). Peninsular India has only one Rattan genus - Calamus.

Distribution : Evergreen forests of Western Ghats form the largest natural home of Rattans. Some species inhabit evergreen and moist deciduous forests as well. Rattans are distributed from sea level to 2000 m, most showing altitudinal preferences. With the exception of *C. rotang* all others are montane. Most of the species are distributed below 1000m and only four species, *C. brandisii, C. gamblei, C. pseudotenuis* and *C. lacciferus* are seen above this level. The present distribution of Calamus in South Indian states is given in Table 1.

Within Peninsular India, Kerala and Karnataka have perhaps the richest assemblage of Rattans. Five species are endemic to Karnataka. Most of the species are concentrated in Kodagu District. Twelve species could be collected from this region alone. In Kerala the species are more or less evenly distributed throughout W. Ghats, 2 species are endemic to Kerala.

There is a steady decrease in the size of the populations during the past 20 years.

At present Rattans are restricted mostly to remote areas. The major reasons for the disappearance of Rattan from forests are (1) An imbalance between demand and supply in favour of the former, (2) Large scale destruction of forests; and (3) Past unscientific exploitation. As there is a continuous and steady pressure on their natural habitat, the broad genetic base is getting reduced alarmingly. eg. *Calamus rheedei* originally described from Rheed's plate (1693) could not be relocated till today. Many species like *C. dransfieldii*, *C. huegelianus* and *C. metzianus* are very much restricted in their distribution (Renuka *et al.*, 1985).

Rattans of Andaman & Nicobar Islands

Rattans occur extensively in both the groups of islands and are represented by 3

Table 1

Distribution of Rattans in South India

Species	Kerala	Tamil Nadu	Karnataka	Andhra Pradesh	Maharashtra	Goa
C. brandisii	+	+	-	-	-	-
C. delessertiarnus	+	-	+	-	-	-
C. dransfieldii	+	-	-	-	-	-
C. gamblei	+	+	+	-	-	-
C. hookerianus	+	+	-	-	-	-
C. huegelianus	+	+	-	-	-	-
C. karnatakensis	-	-	+	-	-	+
C. lacciferus	-	-	+	-	-	-
C. lakshmanae	-	-	+	-	-	-
C. metzianus	+	-	+	-	-	-
C. nagbettai	-	-	+	-	-	-
C. neelagiricus	+	-	-	-	-	-
C. prasinus	-	-	+	-	-	-
C. pseudotenuis	+	+	+	-	-	-
C. rheedei	+	-	+	-	-	-
C. rotang	+	+	-	+	-	-
C. stoloniferus	-	-	+	-	+	-
C. thwaitesii	+	+	+	-	-	+
C. travancoricus	+	+	+	-	-	-
C. vattayila	+	+	+	-	-	-
C. viminalis	-	-	-	+	-	-

+ Present; - Absent

Table 2

Distribution of Rattans in Andaman and Nicobar islands

Species	Andaman	Nicobar
Calamus andamanicus	X	X
C. baratangensis	X	-
C. basui	X	-
C. dilaceratus	-	X
C. longisetus	X	-
C. nicobaricus	-	X
C. palustris	X	-
C. pseudorivalis	-	X
C. semierectus	-	X
C. unifarius	-	X
C. viminalis	X	-
Daemonorops aureus	X	-
D. kurzianus	X	-
D. manii	X	-
D. rarispinosus	X	-
D. wrightmyoensis	X	-
Korthalsia laciniosa	X	X
K. rogersii	X	-

X Present; - Absent

genera, Calamus, Daemonorops and Korthalsia. Korthalsia is absent in the mainland of India. A total of 18 species are reported from these islands (Renuka, 1995) of which 11 are endemic (Table 2).

Distribution : Rattans are widely distributed in the Andaman & Nicobar Islands. While the uninhabited islands are much richer, the inhabited ones also harbour several taxa of Rattans along the boundaries of farms, road sides and in fallow lands.

Of the 18 species reported all but one, *Calamus viminalis* occur most commonly in forests. *C. viminalis* is usually found in scrub jungles and in other open areas. The species are not evenly distributed in the islands (Table 3 and 4).

While, *C. andamanicus* and *K. laciniosa* occur in both the Andaman and Nicobar groups of islands, most others have restricted distribution in certain parts only. 11 species are confined to the Andaman group and 5 to the Nicobar group. Of the latter, *C. pseudorivalis, C. dilaceratus* and *C. unifarius* are seen only in Great Nicobar, while *C. semierectus* in confined to Car Nicobar. In the Andamans, 6 species are confined to the S. Andamans, while *C. basuii* and *D. rarispinosus* are confined to Little Andamans.

Regular extraction of Rattans are taking place from Andaman islands only. Transport bottlenecks save the Nicobar islands from heavy exploitation.

The severe pressure from Rattan industries in India with the unscientific extraction and over exploitation of the raw material resulted in the depletion of Rattan resources at a faster rate in some of the Islands. Hence the resource is bound to dry up in the future.

Rattans of North-Eastern India

Eastern Himalayas and adjoining areas (Sikkim, Arunachal Pradesh, Assam, Meghalaya, Mizoram, Manipur, Tripura and Nagaland), a major mega-diversity area in India, harbour three Rattan genera, Calamus, Daemonorops and Plectocomia. Beccari (1908-1911) reported 20 species and four varieties from this region (Table 5). But during the recent survey only 16 species and two varieties could be relocated. The survey reveals that many species reported earlier from this region are not present now.

Table 3

Distribution of Rattans within Andaman Islands

Species	North Andamans	Middle Andamans	South Andamans	Little Andamans
Calamus andamanicus	X	X	X	-
C. baratangensis	X	X	X	-
C. basui	-	-	-	X
C. longisetus	-	-	X	-
C. palustris	-	-	X	X
C. viminalis	-	-	X	-
Daemonorops aureus	-	-	X	-
D. kurzianus	-	-	X	-
D. manii	-	-	X	-
D. rarispinosus	-	-	-	X
D. wrightmyoensis	-	-	X	-
Korthalsia laciniosa	-	-	X	X
K. rogersii	X	-	X	-

X Present; - Absent

Table 4

Distribution of Rattans within Nicobar Islands

Species	Car Nicobar	Kacchal	Nancoury	Great Nicobar
Calamus andamanicus	-	X	X	X
C. dilaceratus	-	-	-	X
C. nicobaricus	-	-	-	X
C. pseudorivalis	-	-	-	X
C. semierectus	X	-	-	-
C. unifarius	-	-	-	X
Korthalsia laciniosa	-	-	-	X

X Present; - Absent

Distribution : Rattans are found in the evergreen, submontane or the sub Himalayan mixed forest of Assam, Arunachal Pradesh, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, West Bengal and Sikkim. The present distribution pattern of the species in various States are shown in Table 6. All the species reported for the genera Calamus and Daemonorops could be relocated. In Plectocomia, only *P. himalayana* was available. A herbarium check revealed that for the other three species of Plectocomia, no collections were recorded during the past 150 years.

Table 5

Distribution of Rattans in N-E India - Based on Beccari (1908)

Species	Western Himalaya	Eastern Himalaya	Assam	Lower Bengal
Calamus acanthospathus	-	X	X	-
C. erectus	-	-	X	-
C. erectus var. *schizospathus*	-	X	X	-
C. flagellum	-	-	X	-
C. floribundus var. *depauperatus*	-	-	X	-
C. gracilus	-	-	X	-
C. guruba	-	X	X	X
C. inermis	-	X	-	-
C. khasianus	-	X	-	-
C. kingianus	-	X	-	-
C. latifolius	-	X	X	-
C. latifolius var. *marmoratus*	-	-	X	-
C. leptospadix	-	X	X	-
C. nambariensis	-	-	X	-
C. palustris var. *amplissiums*	-	-	-	X
C. tenuis	X	-	X	X
C. viminalis	-	-	X	X
Daemonorops jenkinsiana	-	-	-	-
Plectocomia himalayana	-	X	-	-
P. assamica	-	X	-	-
P. bractealis	-	X	-	-
P. khasiana	-	X	-	-

X Present; - Absent

Most of the species are seen below 500m elevation. With the increasing altitude the number of species of Calamus gradually decreases and at 1700m, only *C. acanthospathus* is seen. At much higher altitudes - around 2000m - the only Rattan growing is *P. himalayana*.

The state of Rattans in North-Eastern States is a matter of great concern. The forest area is diminishing fast primarily due to shifting cultivation and over-exploitation leading to genetic erosion of many species.

Shifting cultivation : Shifting cultivation had been degrading and denuding Indian forests since long. In North-East India about 2.5 million people are involved in shifting cultivation in 2.7 million hectares (Jha, 1997). According to the State Forest Report (1989) the area under shifting cultivation has reduced in Manipur, Meghalaya, Mizoram, Nagaland and Tripura whereas it has increased considerably in Arunachal Pradesh (7.73%) and Assam (74.9%) with in a period of 10 years.

The government owns only upto 10%

Table 6

Present distribution of Rattans in NE States

Species	West Bengal	Sikkim	Assam	Arunachal Pradesh	Megha-laya	Naga-land	Mani-pur	Trip-pura	Mizo-ram
Calamus acanthospathus	X	X	X	X	X	X	-	-	-
C. erectus	X	X	-	X	-	-	-	-	-
C. flagellum	-	-	-	X	X	-	-	-	-
C. floribundus var *depauperatus*	-	-	-	X	X	-	-	-	-
C. gracilus	-	-	-	X	X	-	-	-	-
C. guruba	-	-	-	-	-	-	-	X	-
C. inermis	-	X	-	-	-	-	-	-	-
C. khasianus	X	-	-	X	-	-	-	-	-
C. kingianus	-	-	X	X	X	-	-	-	-
C. latifolius	X	X	X	X	X	-	-	-	-
C. latifolius var. *marmoratus*	-	X	-	-	-	-	-	-	-
C. leptospadix	X	-	X	X	X	-	-	-	-
C. nambariensis	-	-	X	X	-	-	-	-	-
C. tenuis	X	-	X	X	X	X	X	X	-
C. viminalis	X	X	-	-	-	-	-	-	-
Daemonorops jenkinsiana	X	X	X	X	X	-	-	X	X
Plectocomia himalayana	-	X	-	X	-	X	-	X	-

X Present; - Absent

of the forest land in all these States, the rest remaining as private forests. Deforestation is taking place at a very rapid rate due to heavy logging and shifting cultivation. The reduced cycle of shifting cultivation has created environmental hazards like soil erosion and land slides. Thus natural home of Rattans is being destroyed leading to genetic erosion. Many of the species reported earlier are not present now in their reported localities.

Over-exploitation : The demand for Rattan furniture is increasing now-a-days and the existing natural resource is not adequate to meet this, resulting in over-exploitation. Add to this the Rattan industries in South India depend N-E States for their supply of raw material. This also is leading to genetic erosion. In the absence of any large scale plantation, the present situation will lead to extinction of many species.

Many Rattan species have become vulnerable due to habitat destruction and over exploitation. *P. assamica, P. bractealis* and *P. khasiana* could not be relocated in the present survey. The population size of *C. flagellum, C. gracilis, C. guruba, C. inermis* and *C. nambariensis* have considerably decreased during the recent years. Certain species namely *D. jenkinsianus, C. khasianus* and *C. guruba* are cultivated in homesteads. But only three or four economically important species are protected like this.

Diminishing Rattan wealth - its protection and conservation

An analysis of distribution of Rattans in the 3 different major areas in India shows that much change has taken place in its distribution over the years. Many of the species reported earlier from certain localities are not present there now. Even now this trend continues and within the last 10-15 years the range of distribution of Rattans and the population size have diminished drastically.

The exploitation of wild Rattans in increasing with global increase in demand for cane furniture. Consequently this resource is over-exploited and has become short in supply. Presently there is an insufficiency in quantity of Rattans from the natural habitats to meet the demands of the cane industry. Many of the cane industrial units in Southern India are known to get their supplies from N-E India. But the state of forests in N-E India itself is a matter of concern due to shifting cultivation and heavy logging. In Andaman & Nicobar islands also the natural resource is getting depleted at a faster rate due to over exploitation. If the depletion of Rattans continues in the present state, the natural Rattan resources will be almost totally decimated in a few years.

Hence there is an urgent need for habitat preservation for *in-situ* conservation. Effective measures are to be taken to conserve and propagate this group of plants.

In South India the State Forest Departments of Kerala, Karnataka and Goa have started large scale cultivation of Rattans. In N-E States and in Andaman & Nicobar Islands this is yet to be dome. Ecosystem conservation together with large scale cultivation of Rattans will guarantee the conservation of the species.

Acknowledgements

The author would like to express sincere thanks and gratitude to Dr. S. Chand Basha, the former Director of Kerala Forest Research Institute, and Dr. K.S.S. Nair, Director, for their whole hearted support and encouragement during the study period. The field work for this study was carried out with a grant from the International Development Research Centre, Canada which is gratefully acknowledged.

SUMMARY

An analysis of distribution of Rattans in the 3 different major areas in India shows that much change has taken place in its distribution over the years. Even though the reasons differ in each of the 3 major distribution areas, the ultimate result is over-exploitation and habitat destruction. As a result the broad genetic base is getting reduced alarmingly. Hence effective measures are to be taken to conserve and propagate Rattans.

भारतीय रैट्टनों का वितरण - अद्यावधिकरण

सी० रेणुका

सारांश

भारत के तीन बडे-बडे विभिन्न क्षेत्रों में रैट्टनों के वितरण का विश्लेषण करने पर पता चला है कि विगत वर्षों में उनमें बहुत अधिक परिवर्तन हो गया है । यद्यपि इन तीनों बडे-बडे क्षेत्रों में इसके कारणों में अन्तर पाया जाता है फिर भी इसका अन्तिम कारण अतिसमुपयोजन और प्राकृतावास का विनष्ट होना ही है । परिणामतः इसका मुख्य आनुवांशिक आधार बहुत चिन्तनीय गति से घटता जा रहा है । अतः रैट्टनों के संरक्षण और प्रवर्धन के लिए प्रभावकारी उपाय किए जाने चाहिएं ।

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LITTER DECOMPOSITION IN TROPICAL PLANTATIONS : IMPACT OF CLIMATE AND SUBSTRATE QUALITY

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Introduction

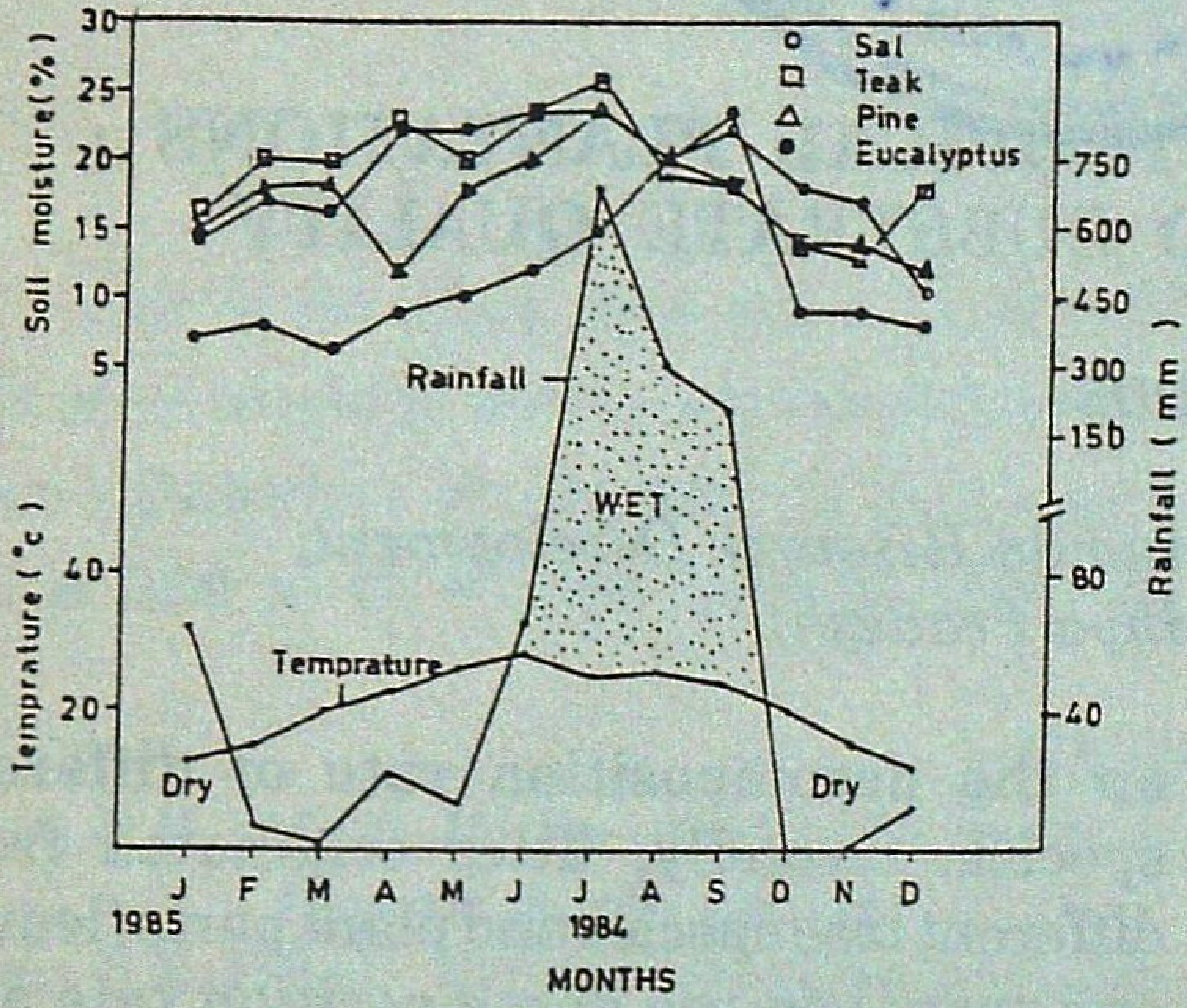
Litterfall and its subsequent decomposition forms the major source of energy and nutrients for the soil and litter organisms of the woodlands. Good knowledge is needed how the climatic factors as temperature and moisture, and chemical composition of the litter material influence the decomposition rate and are to be used in analysing biological or chemical changes in natural or manmade forest ecosystems. The litter decomposing microorganisms are depend on climatic variables viz. rainfall, temperature and chemical constituents of the litter. Thus, two most important controls of litter decomposition rates are probably the prevailing climate and litter substrate quality (Meentmeyer, 1978). Much attention has recently been given to techniques devised for studying decomposition of different types of plant litter in various climatic zones (Edwards and Heath, 1963; van Cleave, 1971; Howard and Howard, 1974; Pande and Sharma, 1993). However, there is still dearth of information defining the role of climate and various groups of chemical composition of litter substrate on the decomposition of litter in turn stand nutrient cycling. Thus, the objectives of this study are; firstly, to evaluate the impact of climatic parameters viz. rainfall, temperature and soil moisture on the decomposition rate of different species; secondly, litter originated from different tree species and plant parts (leaves and twigs) on the decomposition rate and thirdly, the implication of litter decomposition process in relation to substrate and climate on nutrient cycling in terms of mineralization and uptake.

Material and Methods

Study Area : Studies were carried out at Demonstration Area of New Forest Dehra Dun (India), situated at Long. 77° 55"12' Lat. 38° 52"4' and having an altitude of 640 m asl. The mean annual rainfall and temperature over the period of 1960-1984 were 2042 mm and 20°C, respectively. May and June were the hottest, whereas December and January being the coldest months of the year. Bulk of rains occurred during the months of June to September (Fig. 1). The other important features of the plantations are given in Table 1.

Methods : Decomposition of litter of different tree species in their respective stands was investigated by litter bag method. Bags measuring 45 x 25 cm were prepared for this purpose from nylon mesh (2 mm in diameter). Bags were stapled all along the sides at 5 cm intervals leaving enough gap between two staples to ease the entry of most of the macro fauna like arthropods,

Fig. 1



Climatic Diagram of Study Site

annelids, etc., yet the plant material still retained. Five such empty bags were placed on the forest floor at random points and leaf twig ratio under the area covered by those bags was calculated in each plantation, separately.

The freshly senescent leaves and twigs (about 5 mm in diameter) of the main species were taken to the laboratory from plantations and left for two days under room temperature for air drying to attain common moisture content. The air dried plant material (leaves and twigs) were placed in litter bags in calculated amount for each plantation as per their leaf and twig ratio. Five such sub-samples of leaves and twigs, for each species, were also taken for their oven dry weight determination. In all, sixty litter bags were placed at random points in each plantation in such a way that their lower surfaces were in contact with the soil and upper surface, approximately, level the natural surrounding litter. The bags were placed on 15th (Pine and Teak) and 16th (Sal and Eucalypts) December, 1982. The bags from each plantation were retrieved at monthly intervals. Last set of bags from Pine and Teak plantation were collected on 14, December 1983, whereas these were collected from Sal and Eucalypt plantations, on the next day. All samples were brought to the laboratory in polythene bags and made them free from the foreign materials. The fresh weight of the samples were determined and kept on oven drying at 80°C till constant weight.

Samples of litter decomposition from litter bags were analysed for nitrogen (N) by Kjeldahl method (Piper, 1942). Phosphorus (P) by Molybdate blue method (Vogal, 1961), potassium (K) and calcium (Ca) by EEL flamephotometer and magnesium (Mg) using atomic absorption spectrophotometer. Organic matter constituents were determined as per the scheme followed by Pande and Sharma, 1989. All the results are presented on oven dry weight basis and are the mean of three samples.

Table 1

Main characteristics of the plantations

Name of plantations	Year of plantations	Area (ha)	Average DBH (cm)	Number of trees/ha	Litterfall (kg/ha/yr)
Shorea robusta	1926	0.23	26.97	700	11271
Tectona grandis	1926	0.30	28.80	410	6950
Eucalyptus spp.	1972	1.13	9.10	1700	1071
Pinus roxburghii	1926	0.50	38.12	384	9676

Table 2

Decomposition constants and time required for the one half and 95% of the original dry weight for Tectona grandis (Teak), Shorea robusta (Sal), Pinus roxburghii (Pine) and Eucalyptus

Species	Component	k	Decay parameter k'	Time required (in years)	
				Half life (0.693/k)	95% (3/k)
S. robusta	Leaf	1.67	0.81	0.41	1.80
	Twigs	0.95	0.61	0.73	3.17
T. grandis	Leaf	1.65	0.81	0.42	1.81
	Twigs	0.97	0.62	0.71	3.08
Eucalyptus spp.	Leaf	1.16	0.67	0.59	2.57
	Twigs	0.82	0.56	0.84	3.64
P. roxburghii	Leaf	1.35	0.74	0.81	2.23
	Twigs	0.86	0.58	0.80	3.46

Note: The parameter Kkand k' were calculated from weight loss during 12 months periods by the formula (Olson, 1963) $x/x^o = 1\text{-}e^{kt}$ (where x^o = initial weight and x = weight remaining after the time t)

Table 3

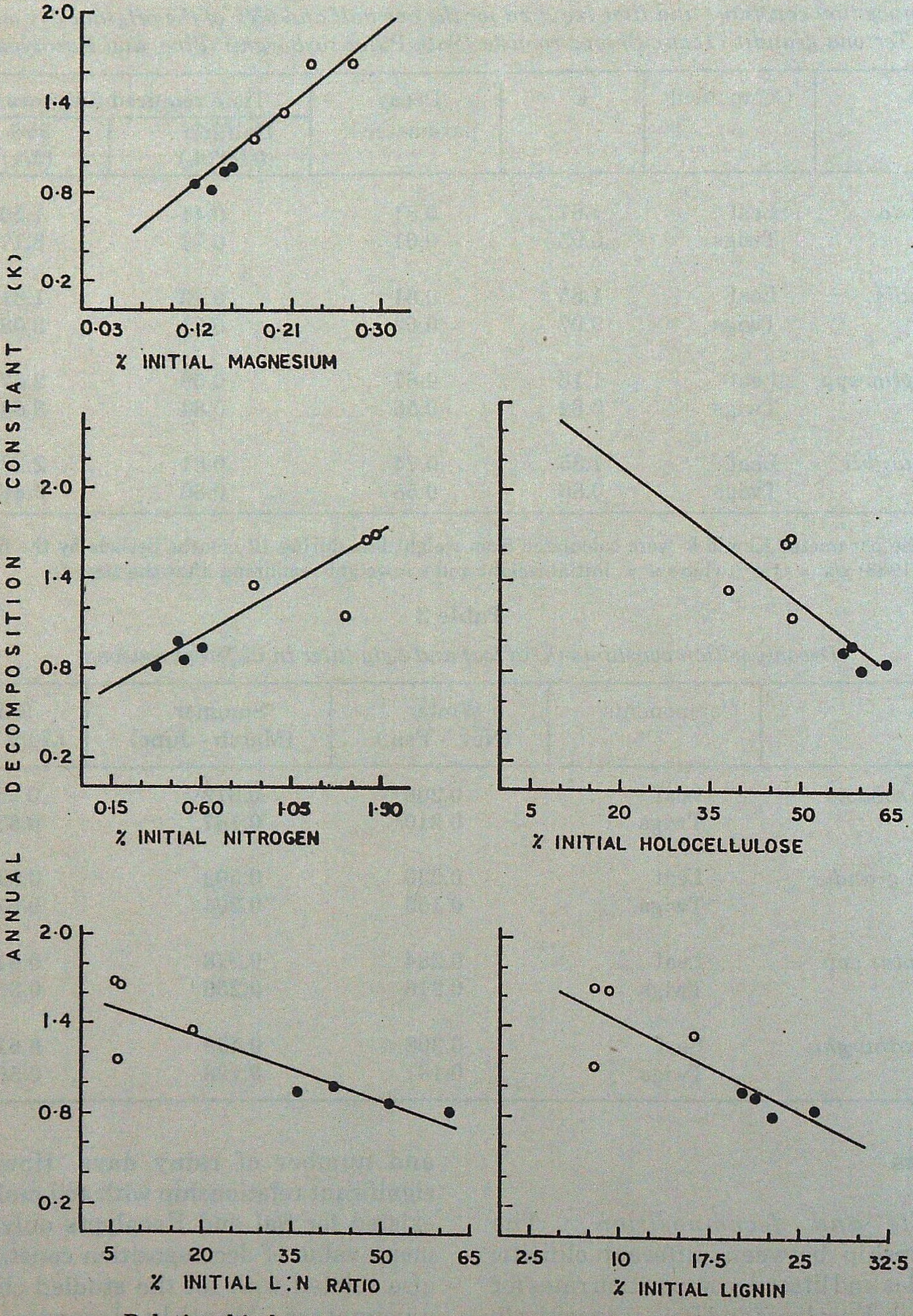
Decomposition constants (k) of leaf and twig litter in different seasons

Species	Components	Winter (Nov. - Feb.)	Summer (March - June)	Rains (July - Oct.)
Shorea robusta	Leaf	0.206	0.612	0.85
	Twigs	0.210	0.167	0.57
Tectona grandis	Leaf	0.239	0.502	0.91
	Twigs	0.183	0.204	0.57
Eucalyptus spp.	Leaf	0.284	0.278	0.61
	Twigs	0.216	0.256	0.35
Pinus roxburghii	Leaf	0.208	0.439	0.61
	Twigs	0.181	0.128	0.56

Results

Climate and decomposition : The relationship between different climatic variables and litter decomposition rates for Sal, Teak, Eucalypts and Pine are positively related with rainfall, mean temperature and number of rainy days. However, significant relationship with soil moisture existed for Sal and Eucalypts only. The mean value of decomposition constant in also related with all the studied climate parameters. Monthly decomposition constant (K) of leaf litter is positively

Fig. 2



Relationship between Annual Decomposition Constant and the % initial chemical constituents (●Twig, o Leaves)

Table 4

Correlation coefficient and their possible regression equations between leaf litter decomposition constant (K) and different climatic variables

Characters	Regression equation	Correlation coefficient (R^2)
Rainfall vs K of Teak	-	N.S.
Rainfall vs K of Sal	$Y = 0.08942 + 0.00031 X$	0.64*
Rainfall vs K of *Eucalyptus*	$Y = 0.07204 + 0.000250 X$	0.71**
Rainfall vs K of Pine	$Y = 0.06042 + 0.000169 X$	0.59*
Rainfall vs mean K	$Y = 0.08171 + 0.000249 X$	0.71**
No. of rainy days vs K of Teak	-	N.S.
No. of rainy days vs K of Sal	$Y = 0.05248 + 0.00945 X$	0.75**
No. of rainy days vs K of *Eucalyptus*	$Y = 0.04955 + 0.00683 X$	0.74**
No. of rainy days vs K of Pine	$Y = 0.05048 + 0.00511 X$	0.68*
No. of rainy days vs mean K	$Y = 0.04918 + 0.00791 X$	0.87**
% soil moisture vs K of Teak	$Y = -0.1562 + 0.01533 X$	0.59*
% soil moisture vs K of Sal	$Y = -0.2124 + 0.01867 X$	0.82**
% Soil moisture vs K of *Eucalyptus*	$Y = -0.10192 + 0.01265 x$	0.62**
% soil moisture vs K of Pine	$Y = -0.00489 + 0.0083 X$	0.74**
Mean temp. (°C) vs K of Teak	$Y = -0.10913 + 0.0126 X$	0.78**
Mean temp. (°C) vs K of Sal	$Y = -0.14551 + 0.0145 X$	0.89***
Mean temp. (°C) vs K of *Eucalyptus*	$Y = -0.02499 + 0.0062 X$	0.64*
Mean temp. (°C) vs K of Pine	$Y = -0.06956 + 0.00928 X$	0.78**
Mean temp. (°C) vs mean K	$Y = -0.08759 + 0.01068 X$	0.91***

Note: N.S. - Not significant; * - significant at 5% probability level; **- significant at 1% probability level; *** -significant at p.1% probability level.

related with temperature and soil moisture in all the four plantations and is also positively related with rainfall excepting Teak. Moreover, significant positive relationship was obtained with number of rainy days for Sal, Pine and Eucalypts.

The multiple correlation (R^2) between monthly decomposition constant (K) rainfall (x1) and mean monthly temperature (x2) was significant for Teak, Sal, Pine and their pooled mean of the four species (Table 5).

Substrate and decomposition : The value of annual decomposition constants (K) of leaf and twig litter of the four species are pooled for their correlation with their respective

Table 5

Multiple correlation between decomposition rate (K) and climatic variables

Characters	Multiple regression equation (X1 = rainfall; X2 = temperature)	Multiple correlation coefficient (R^2)
K for Teak	$Y = -0.099890 + 0.000035X1 + 0.001184X2$	0.61*
K for Sal	$Y = -0.130787 + 0.000056X1 + 0.013329X2$	0.80***
K for *Eucalyptus*		N.S.
K for Pine	$Y = -0.036170 + 0.00001252X1 + 0.006545X2$	0.68**
Mean K	$Y = -0.067450 + 0.000076X1 + 0.00903X2$	0.086***

Note: N.S. - Not significant, * - significant at 5% probability level, ** - significant at 1% probability level; *** - significant at 0.1% probability level.

Table 6

Initial chemical composition (%) of leaf and twig litter of different tree species (each value is mean of three replicates)

Species Chemical constituents	Leaves				Twigs			
	Sal	Teak	*Eucalyptus*	Pine	Sal	Teak	*Eucalyptus*	Pine
Nitrogen	1.45	1.42	1.31	0.88	0.60	0.48	0.37	0.51
Phosphorus	0.064	0.13	0.059	0.06	0.057	0.08	0.05	0.49
Potassium	0.37	0.88	0.64	0.28	0.23	0.67	0.34	0.24
Calcium	1.30	1.43	1.77	1.03	1.30	1.57	1.33	0.93
Magnesium	0.27	0.23	0.17	0.20	0.14	0.15	0.13	0.11
A.S.E.	6.15	1.47	6.21	4.33	3.05	0.14	4.26	1.70
E.S.E.	5.71	4.86	8.07	3.84	2.41	0.95	1.81	2.23
H.W.S.E.	9.002	5.07	10.71	4.62	7.93	2.60	4.88	4.07
Holocellulose	48.20	47.02	48.57	38.07	57.0	58.37	60.20	64.20
Lignin	7.90	9.35	7.83	16.30	21.56	20.22	22.67	26.27

initial substrate quantity. Table 6 shows initial chemical composition of the leaves and twigs of four species. Nitrogen and magnesium is positively related with decomposition rate (K) while lignin, holocellulose and lignin/nitrogen ratio is negatively related (Table 7; Fig.2).

Phosphorus, calcium, potassium, ether soluble extractives (E.S.E.) alcohol soluble extractives (A.S.E.) hot water soluble extractives (H.W.S.E.) are not significantly

Table 7

Correlation coefficient and their possible regression equations between annual decomposition constant (K) of leaf and twig litter and their initial chemical constituents (n = 8)

Chemical constituents	Regression equation	Correlation coefficient (R^2)
Alcohol soluble extractives	-	0.29 N.S.
Ether soluble extractive	-	0.26 N.S.
Hot water soluble extractive	-	0.30 N.S.
Lignin	$Y = 1.83-0.039 X$	-0.84**
Holocellulose	$Y = 2.76-0.299 X$	-0.75**
Lignin/Nitrogen ratio	$Y = 1.56-0.013 X$	-0.87**
Nitrogen	$Y = 0.539-0.79 X$	-0.96***
Phosphorus	-	0.63 N.S.
Calcium	-	0.21 N.S.
Potassium	-	0.42 N.S.
Magnesium	$Y = 0.169 + 5.773 X$	0.95***

Note : N.S. - Not significant; * - significant at 5% probability level; ** - significant at 1% probability level; *** - significant at 0.1% probability level; X - chemical constituents; Y- decomposition constant.

related with decomposition rate (K) (Table 7).

Discussion

Moisture is one of the most important determinants in decomposition process (Van der Drift, 1963). Moisture regime in a stand depends upon many abiotic and biotic factors, viz. rainfall, amount of radiation received on the forest floor, its aridity, humidity, temperature are amongst the abiotic factors, whereas structure and function of the stand cover biotic factors. With this, it is probable that under the Eucalypts stand, which is more exposed to radiation, loosely packed and with the no other associates, the microclimatic conditions would definitely be different than those of the other stands, which are more stocked and having closed canopy provides lesser exposure to the forest floor for radiation and also reduces run-off under the stand. Consequently, moisture and other micro-climatic conditions are not congenial for the faunal and microbial activity in the Eucalypts stand, which is probably responsible for its lower decay rate even than the Pine (Table 2).

The seasonal variation in the decomposition constants (K) is given in Table 3. The rapid decay rate during rainy season in all the species appears to be the combined effect of moisture and temperature, which is further confirmed by significant multiple correlation coefficient (R^2) between decomposition constant (K), rainfall and temperature. Singh and Gupta (1977) have also reported greater weight loss from detritus confined in the litter bags during the rainy season in tropical grassland. While, low decay rate during winter is probably the effect of lowering of the temperature. The decay rates of all the species during summer were generally lower than of the rainy season, but in case of Eucalypts it was exceptionally low, which could be attributed to its exposed canopy and moisture limitations.

The initial chemical constituents of the litter, physical structure of tissues and their proportionate variation in plant organs like leaves, twigs fruit seeds, etc. have profound effect on the decay rate (Swift *et al.*, 1979). Referring to Fig. 2 and Table 7, it could be noticed that the rate of decomposition of leaves and twigs are correlative to the number of initial chemical constituents. These correlations are obviously due to the wide chemical as well as structural differences in litter components viz. leaf and twigs. In the present study, it has also been noticed that nitrogen and magnesium are positively related with decay rate. During the decomposition process, carbon is used as energy source by decomposers, while nitrogen is assimilated into cell proteins and other components. Thus, a higher initial nitrogen promotes decomposition as has been suggested by a number of investigators (Waksman and Tenney, 1927; Witkamp, 1966; Satchell and Lowe, 1967). While, the role of magnesium has not been defined in the decomposition process however it is assumed that this nutrient is required by the decomposer organisms for their metabolic activities because substantial amount of this element was found in the elemental composition of the decomposer organisms (Swift *et al.*, 1979). Moreover, the negative significant relationship with lignin and lignin/nitrogen ratio indicate more influence of lignin on decomposition process than of the nitrogen. The similar conclusion was also drawn by Melillo *et al.* (1982). As far as substrate quality is concerned, it is expected that combined chemical constituents in their different proportion and structural specificity may affect the rate of decomposition (Clark and Paul, 1970).

Though, the Eucalypts leaves contain higher per cent of nitrogen and lower lignin than of the Pine, showed lower decay rate than the latter. Since the macroclimatic conditions were same for all the stands, however, their prevailing micro-climatic conditions would definitely be different due to the differences in structure and composition of the stands. This change in microclimate would affect the activity of those micro-organisms which are responsible for decomposition process. Further, the differential action of base rich and acid rich litter has been emphasised for its decomposability. It has been found that the base rich litter decompose earlier than of the acid rich litter. This may be due to the proportionate change in the population of microfauna as per the litter quality (Gosz, 1984). Litter with higher base content is less acidic, less able to complex proteins and much easier to decompose (Swift *et al.*, 1979; Gosz, 1984). To this, it can be added that the microclimatic conditions, which are so created in the stand by the presence of deciduous species, which are suppose to increase the microfaunal population and are thus responsible for the enhancement in decomposition rate as it is evident from the Pine stand. The beneficial effect of hardwood mixture in Spruce stand in Sweden appeared even after the hardwoods had disappeared (Lutz and Chandler, 1946). Therefore, the mixing of deciduous species could become an efficient measure in the management of plantations with regards to the efficient nutrient cycling in terms of mineralisation and uptake.

SUMMARY

The present paper deals with the decomposition rate of four tree species viz. *Shorea robusta* (Sal), *Tectona grandis* (Teak), *Eucalyptus* spp. (Eucalypts) and *Pinus roxburghii* (Pine) in relation to their chemical composition and climatic factors. Leaf litter decomposition followed the order : Sal (1.67) > Teak (1.65) > Pine (1.35) > Eucalypts (1.34). In general, values for higher decomposition rate were observed during rainy season and lowest during winter except Pine and Sal, where these lower values were obtained during summer season. Invariably, rainfall, number of rainy days, soil moisture and temperature showed positive correlation with decomposition rate. The multiple correlation (R^2) showed that cumulative effect of rainfall and temperature was also positively significant. As far as chemical constituents of litter are concerned N and Mg is positively related with decomposition rate while Lignin, Holocellulose and Lignin/Nitrogen ratio showed negative correlation with decomposition rate. No correlation was obtained with P, Ca, K, alcohol soluble, ether soluble and hot water extractives.

उष्णादेशीय रोपवनों में आस्तरण का विघटन - उस पर जलवायु और उपस्तरीय गुणवत्ता का प्रभाव

पी०के० पाण्डे

सारांश

प्रस्तुत अभिपत्र में चार वृक्ष जातियाँ अर्थात् *शोरिया रोबस्टा* (शाल), *टैक्टोना ग्रांडिस* (सागौन), *युकेलिप्टस* की जातियाँ (युकेलिप्टस) और *पाइनस राक्सबर्घिआई* (चीड़) के आस्तरण के विघटन की दर का विवेचन उनके रासायनिक गठन और जलवायु कारकों के संबन्ध में रखकर किया गया है। पर्णास्तरण का विघटन इस अनुक्रम से होता मिला : शाल (1.67)> सागौन (1.65) >चीड़ (1.35)> युकेलिप्टस (1.34)। सामान्यतः विघटन होने की अधिक दर वर्षा ऋतु में और न्यूनतम दर सर्दियों में होती मिली सिवाय चीड़ और शाल के जहाँ इसकी न्यूनतम अर्हाएँ गर्मियों में होती मिली। स्पष्टतः वर्षा, बरसात पड़ने वाले दिनों की संख्या, मृदा नमी और तापमान का विघटन होने की दर के साथ धनात्मक सहसंबन्ध है। बहुसहसंबन्धों (R^2) ने दिखाया कि वर्षा और तापमान का संचयी प्रभाव भी धनात्मक दृष्टि से सार्थक या महत्वपूर्ण है। जहाँ तक आस्तरण के रासायनिक गठन की बात है नाइट्रोजन और मैग्नीशियम का विघटन की दर के साथ धनात्मक संबन्ध है जबकि लिग्निन, सर्वकोशाधु तथा लिग्निन / नाइट्रोजन अनुपात का विघटन की दर के साथ ऋणात्मक सहसंबन्ध पाया गया। एल्कोहल विलेय, ईथर विलेय और गरम पानी से निकले निस्सार्यों के साथ फास्फोरस, कैलशियम और पोटाशियम का कोई सहसंबन्ध रहता नहीं पाया गया।

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EFFECT OF STORAGE ON SEED VIABILITY IN SOME LEGUMINOUS TAXA

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Introduction

Successful regeneration of plants depends on quality of seeds, their viability and vigour, which ultimately depend on storage system for their conservation. The relationship between the storage, environment and influence of packing over germination and loss of seed viability has been analysed in detail by Popovska *et al.* (1981). The potential storage life of seed varies from species to species (Harrington, 1972; Agrawal, 1980) and within species, from variety to variety (Agrawal, 1977, 1979) under the same storage condition. Therefore to know the effect of storage on seed viability of 26 leguminous taxa, seeds of each taxa were stored at different temperature with 6 to 9 per cent moisture and then studied for their viability as well as germinability for continuously 7 years (1990-96).

Material and Methods

Mature seeds of 26 leguminous taxa were collected and stored at different temperatures. Seeds of one lot of each species were kept in the air tight bottles and stored in refrigerator having approximate temperature 3-5°C and at room temperature 20-40°C. Another lot of seeds was kept in brown paper bags. One bag of seeds of each taxa was stored at room temperature and another in refrigerator.

The highest relative humidity occurred between August to October and lowest between April to June. Viability of seeds was expressed by average results of germinability and 2, 3, 5 triphenyle tetrazolium chloride test. Both the viability tests were conducted after every 3 months upto 7 years (1990-1996). For the germination tests five replicates of 25 seeds of each lot were surface sterilized by soaking in 1% mercuric chloride solution for 5-10 min. and then germinated in petridishes in laboratory and in earthen pots under natural conditions. For the treatment with 2, 3, 5 triphenyle tetrazolium chloride seeds were randomly taken from each lot and soaked in water over night. Soaked seeds of each lot were treated with 1% aqueous solution of 2, 3, 5 triphenyle tetrazolium chloride. Well stained seeds were evaluated as viable seeds.

Observations and Results

Storage at room temperature

(i) *Stored in airtight Bottle* : At the ambient temperature seeds of the 4 taxa i.e. *Bauhinia purpurea, Leucaena glauca, Prosopis juliflora* and *Pithecellobium dulce* remained highly viable whereas seeds of 4 taxa i.e. *Cassia glauca, Caesalpinia coriraria, Mimosa pudica* and *Peltoforum ferrugineum* showed poor viability. Rest of the eighteen leguminous taxa lost their viability after seven years of storage (Table 1).

(ii) *Stored in paper bags* : Results were almost same as above.

Storage in refrigerator

Seed viability of the following taxa was greatly influenced by the low temperature of refrigerator.

After the storage for 24 months, seeds of *Acacia catechu* remained viable and showed 100% germinability, of *Dalbergia sissoo* lost their viability after six months and of *Sesbania aegyptiaca* also lost their viability but after 2 years (Table 1).

Table 1

Yearly viability percentage of seeds of 26 Leguminous taxa (based on average results of germinability and 2, 3, 5 triphenyle tetrazolium chloride test)

Sl.No. Species	Viability percentage/year						
	1990	1991	1992	1993	1994	1995	1996
1. *Albizia lebbek* (Linn) Benth.	35	30	20	15	10	5	5
2. *A. lucida* (Roxb.) Benth	20	10	10	0	0	0	0
3. *A. procera* (Roxb.) Benth	30	25	20	10	0	0	0
4. *Acacia catechu* (Linn f.) Willd.	50	80	30	15	0	0	0
5. *A. arabica* Willd.	15	10	10	5	0	0	0
6. *Abrus precatorius* L.	40	30	25	15	10	2	0
7. *Bauhinia purpurea* L.	90	75	60	50	50	35	35
8. *Butea monosperma* (Lamk) Taub.	100	100	100	60	40	15	12
9. *Cassia occidentalis* L.	80	80	75	70	25	0	0
10. *C. tora* L.	60	60	50	50	30	0	0
11. *C. glauca* Lam.	70	70	65	50	35	10	8
12. *Caesalpinia coriraria* (Jacq.) Willd.	75	70	70	55	35	12	12
13. *Clitoria ternatea* Linn.	80	75	60	25	10	0	0
14. *Dalbergia sissoo* Roxb. ex DC.	100	100	85	35	0	0	0
15. *D. lanceolaria* Linn.	25	20	20	10	5	0	0
16. *D. lanceolata* Zipp.	55	50	50	20	5	0	0
17. *Delonix regia* (Boj ex Hook) Raf.	20	15	2	0	0	0	0
18. *Erythrina indica* Lamk	60	50	30	5	0	0	0
19. *Leucaena glauca* (Willd) Benth.	85	85	80	70	70	40	30
20. *Mimosa pudica* Linn.	25	25	20	20	15	10	10
21. *Peltoforum ferrugineum* (Decne.) Benth.	30	30	25	20	15	8	15
22. *Parkensonia aculeata* Linn.	80	60	60	50	5	0	0
23. *Pithecellobium dulce* (Roxb.) Benth.	90	85	80	70	60	35	35
24. *Prosopis juliflora* (S.W.) DC.	75	70	50	50	45	20	20
25. *Sesbania aegyptiaca* (Poir.) Pers.	35	30	20	10	0	0	0
26. *Vicia hirsuta* (Linn.) Zipp.	80	80	70	30	10	0	0

Discussion

Seeds of 9 leguminous taxa stored in refrigerator maintained their viability for the longer period because of low relative humidity and temperature. The important factors which determine the viability of seeds in storage system were seed moisture content and temperature. Seeds stored at room temperature lost their viability rather rapidly as compared to those kept in refrigerator and thus affecting their longevity.

Generally the process of seed deterioration was faster and greater at ambient storage but the effect of temperature varied species to species. Some species lost their viability at room temperature, while some lost at low temperature of refrigerator after the continuous storage of seven years, e.g. seeds of *Dalbergia sissoo* when stored in refrigerator lost their viability while at room temperature they showed 35% viability after the same storage period of six months. Seeds of *Acacia catechu* showed 20% viability at room temperature after the storage of 18 months, while seeds kept in refrigerator showed 80% viability upto the storage of 24 months and showed 100% germination. Variation in the viability of stored seeds depends on the initial moisture in the seeds and the atmospheric humidity at the time of storage. The rate of deterioration was rather slow under low moisture content. The longevity of seed viability varies from taxa to taxa and even species to species under the same packing and storage conditions e.g. *Albizia lebbek* showed 5% viability (stored at room temperature) at the end of 7th year of storage, while under same condition seeds of *Albizia lucida* lost their viability after 36 months of storage (Table 1).

The seeds of twenty six leguminous taxa which are studied here, took variable time for their complete loss of viability under different storage conditions because seed deterioration of different tree species depends on various factors. These factors act differently upon individual seed. The nature of the seed like its chemical composition, seed coat characteristics and genetic composition of each species is differently responsible for its longevity under identical storage conditions.

Finally it was concluded that out of 26 taxa only 9 taxa namely *Bauhinia purpurea, Butea monosperma, Cassia glauca, Caesalpinia coriraria, Leucaena glauca, Mimosa pudica, Peltoforum ferruginium, Pithecellobium dulce* and *Prosopis juliflora* remained viable after the storage of six to seven years. Such a study is helpful for establishing the seed gene banks. These banks would help to the plant breeders to preserve the germplasm of a particular species for a definite period under definite storage conditions.

Acknowledgements

The author is grateful to Dr. P.V. Sane, Director, National Botanical Research Institute, Lucknow for providing the necessary facilities.

SUMMARY

Effect of storage on seed viability of 26 leguminous taxa at different temperatures was studied continuously for seven years (1990-1996). Average of the results of tetrazolium test and seed germinability was expressed as seed viability. It varied from species to species and variety to variety even under the same storage conditions.

लैग्युमिनस के कुछ पौधों के बीज की जीवक्षमता पर भण्डारण का प्रभाव

कनक सहाय

सारांश

लैग्युमिनस के 26 पौधों के बीज की जीवक्षमता पर विभिन्न तापक्रमों पर भण्डारण के प्रभाव का लगातार 7 वर्षों (1990-1996) तक अध्ययन किया गया । बीज की जीवक्षमता टेट्राजोलियम परिक्षण एवं अकुंरण योग्यता के परिणामों के रूप में व्यक्त की गई । यह समान भण्डारण परिस्थिति में भी जाति से जाति एवं प्रजाति से प्रजाति तक परिवर्तित होती रही ।

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EFFECT OF SEED WEIGHT ON GERMINATION AND INITIAL SEEDLING GROWTH IN *ALBIZIA SAMAN* (JACQ.) F. MUELL.

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Introduction

Albizia saman (Jacq.) F. Muell. (formerly classified as *Samanea saman*, *Pithecellobium saman* and *Enterolobium saman*) is popularly planted as an avenue tree along roadsides, boundary lines of village markets and homesteads in Bangladesh. The species is found in the tropics from sea level to 1000 m and grows best in moist, well drained fertile soils (Hensleigh and Holaway, 1988). The species is usually propagated from the seeds, seedlings raised in the nursery and outplanting the polybag seedlings is the most common planting practice. The fruit is a pod, 12-22 cm long x 1.5 cm, septate and indehiscent possessing different size and weight seeds. Seeds of *A. saman* have hard, impermeable seedcoats. Sowing the mixed seeds of the species may result in non-uniform seedlings which may lead to heterogeneity in the vigour and size of the seedlings. The seed size often controls the germination and initial seedling growth in plant species (Langdon, 1958; Wood *et al.*, 1977; Kandya, 1978; Kumar, 1979) and reports are that usually bigger seeds germinate faster and attained enhance growth than the smaller ones (Whuangplong *et al.*, 1994; Quraishi *et al.*, 1996). In order to see the effect of seed weight of *A. saman* on germination and initial seedling growth, an attempt was made to establish the relationship between the seeds of different weight groups and their germination capacities, early seedling growth and dry matter production under nursery conditions at the Institute of Forestry and Environmental Sciences, Chittagong University.

Material and Methods

The seeds were collected from the Silvicultural Research Division of Bangladesh Forest Research Institute, Chittagong, Bangladesh. The seed extraction was done manually and after cleaning, sound seeds were retained. Each seed was weighed on an electronic balance of 0.001g accuracy and depending upon the availability of seed weight, the seeds were divided in the following three classes : C_1 (0.11 - 0.16g), C_2 (0.17 - 0.23g) and C_3 (0.24 - 0.32g) having a mean weight of 0.137, 0.205 and 0.301g respectively.

The seeds of each class were tested for germination and initial growth of the seedlings in polybags at the Institute nursery. 150 seeds divided into 5 replicates of 30 seeds each were used for germination test under each class. Germination was recorded daily after the commencement till it was over after 2 weeks. 45 random seedlings from each class were harvested for the assessment of stem height (cm), collar diameter (mm), root length (cm), root, stem and leaf fresh and dry weight of the seedlings. The Quality Index (QI), as developed by Dickson *et al.* (1960) to quantify seedling morphological quality was calculated as follows :

QI = Seedling dry weight (gm) / [(ht in cm/ diameter in mm) + shoot DW/root DW)].

Results and Discussion

The seeds of the three different weight classes (C_1, C_2 and C_3) range from 0.11 - 0.32g (Table 1). Germination starts

Table 1

Seed weight classes showing the seed variations and germination per cent in Albizia saman

Seed weight classes	C_1 (small)	C_2 (medium)	C_3 (large)
Seed weight ranges (g)	0.11 - 0.16	0.17 - 0.23	0.24 - 0.32
Mean weight of the seeds (g)	0.137 ± 0.005	0.205 ± 0.004	0.301 ±0.006
Mean width of the seeds (cm)	0.419 ± 0.010	0.463 ± 0.008	0.533 ±0.007
Mean length of the seeds (cm)	0.818 ±0.021	1.02 ±0.072	1.171 ±0.022
Germination %	58 ± 2	61 ± 2	65 ± 3

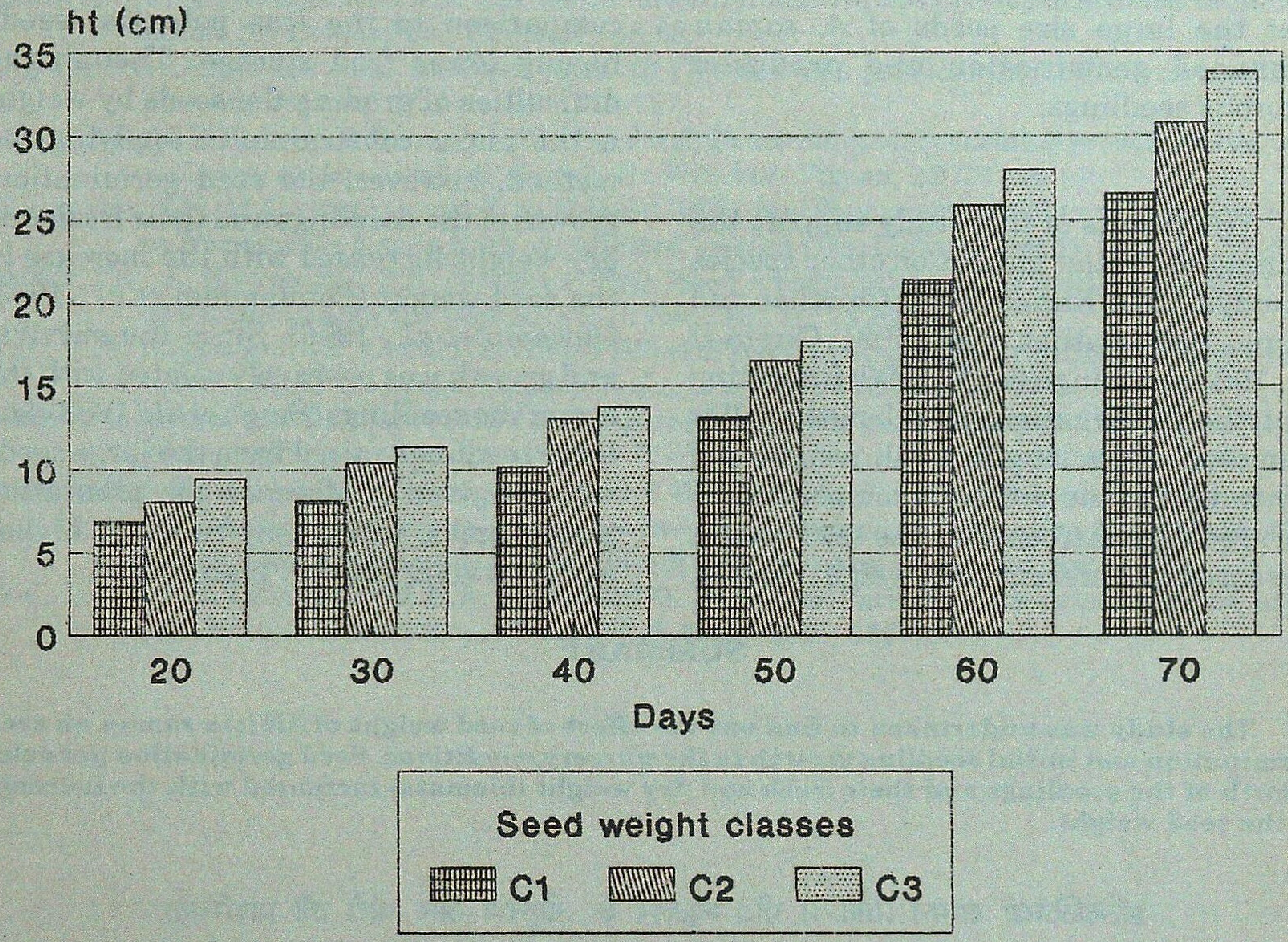
Table 2

Different components of the seedlings raised from the different seed weight classes in Albizia saman

Seedling components	Seed weight classes		
	C_1 (small)	C_2 (medium)	C_3 (large)
Seedling mean height (cm)	26.60 b*	30.80 a	33.90 a
Mean Collar dia. (mm)	4.20 c	5.40 b	6.20 a
Mean Root length (cm)	27.17 c	34.03 b	41.80 a
Root fresh weight (g)	4.75 b	10.31 a	12.22 a
Stem fresh weight (g)	2.95 b	5.02 a	6.43 a
Leaf fresh weight (g)	6.62 b	11.20 a	13.40 a
Total fresh wt./seedlings (g)	14.32 b	26.53 a	32.05 a
Root dry weight (g)	0.92 b	2.08 a	2.49 a
Stem dry weight (g)	0.82 c	1.44 ab	1.89 a
Leaf dry weight (g)	1.78 c	3.10 ab	3.56 a
Total dry wt./seedlings (g)	3.52 c	6.62 ab	7.94 a
Seedling Quality Index (QI)	0.385 c	0.84 ab	1.04 a

* : Figures followed by the same letter(s) do not vary significantly at the 5% probability level, Duncan's Multiple Range Test (DMRT).

Fig. 1



The height meaurement (cm) of the seedlings raised from three different seed weight classes showing the trend of increased height growth for large size seeds.

immediately after 3 days of sowing the seeds and completes within 12 days. The germination per cent was affected by seed weight classes as 58%, 61% and 65% for C_1, C_2 and C_3 respectively. The germination per cent of the seeds increased as the seed size and weight increased (Table 1). At the age of 10 weeks of the seedlings, the seedling height was 26.6, 30.8 and 33.9 cm respectively for C_1, C_2 and C_3 classes. Though there are differences in seedling height between C_2 and C_3 treatments but the differences are not significant, whereas C_1 seedlings attained significantly lower height (26.6 cm). The height increment of the seedlings of the three different classes taken at 10 days interval till 70 days, seedlings also showed the same trend of higher height increment (Fig. 1) for large seeds.

Seedlings harvested from all the three different classes showed the differences among the mean seedling height (cm), collar diameter (mm), root length (cm), root fresh weight (g), stem fresh weight (g), leaf fresh weight (g), root dry weight (g), stem dry weight (g), leaf dry weight (g) and Quality

Index (QI) of the three different classes (Table 2). In all cases, the results indicate that the large size seeds of *A. saman* enhanced germination and produced vigorous seedlings.

The results of this study support the findings of similar studies on other species (Kandya, 1978; Kumar, 1979; Chauhan and Raina, 1980; Pathak *et al.*, 1981; Gupta *et al.*, 1983 and Singh *et al.*, 1990) indicating that the germination, root length, collar diameter, shoot length, fresh weight and dry weight of the different components of the seedlings increased as the seed weight increased in different seed weight classes.

The higher growth could be the attribute of large seeds having higher food storage in comparison to the less potential seeds having lower food storage. Though the difficulties of grading the seeds by weight is the major constraints in applying the method, however, the seed germination, growth of the seedlings and their fresh and dry weight increased with the increase in the seed weight (Ponnammal *et al.*, 1993; Quraishi *et al.*, 1996). Since the survival and growth was positively related with the size of the seedlings (Singh *et al.*, 1988), the large seedlings raised from the large seeds will be given preference for plantation programmes, which may result in higher early survival rates in plantations.

SUMMARY

The study was undertaken to find out the effect of seed weight of *Albizia saman* on seed germination and initial seedling growth in the nursery conditions. Seed germination per cent, growth of the seedlings and their fresh and dry weight (biomass) increased with the increase in the seed weight.

एल्बिज्जिया सामन (जैक०) पी० म्यूल्लर के अंकुरण और पौधे की प्रारम्भिक वृद्धि पर बीजों के भार का प्रभाव

एम०जेड०यू० निजाम व एम०के० हुसैन

सारांश

यह अध्ययन *ए० सामन* के बीजों के भार का रोपणी दशाओं में उनके अंकुरण और पौधों की प्रारम्भिक वृद्धि पर पड़ने वाला प्रभाव मालूम करने के लिए किया गया । बीजों का भार बढ़ने के साथ उसके बीजों का अंकुरण प्रतिशत्, पौधों की बढ़वार और उनके ताजा और शुष्क भार (जैवपुंज) में भी वृद्धि हुई ।

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EFFECT OF SOIL SALINITY AND SODICITY ON SEEDLING GROWTH AND MINERAL COMPOSITION OF *PONGAMIA PINNATA*

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Introduction

Tolerance of *Pongamia pinnata* to soil salinity and sodicity under field conditions had been reported (Yadav and Singh, 1970; Garg and Khanduja, 1979), but the data on performance of this species at varying levels of soil salinity and sodicity under all conceivable environmental conditions of the country are not available. In view of the scope of growing *Pongamia pinnata* on moderately salt affected soils for multifarious uses like leaves for fodder and manure, pods for fodder, seeds for Pongam oil and cake, wood for fuel and odd agricultural implements, present investigation was carried out to study the performance of *Pongamia pinnata* in early stages of growth at varying levels of salinity and sodicity and their effect on uptake of cations.

Material and Methods

Response of *Pongamia pinnata* was evaluated by carrying out two separate sets of experiments, viz. (i) with varying levels of soil salinity (ECe), and (ii) with varying levels of soil sodicity (ESP) in glazed earthen pots each filled with 10 kg soil. The salinity levels were created artificially in a normal silty clay loam soil: Fine-loamy mixed hyperthermic Typic Ustochrept (clay 29.4%, silt 39.2% and sand 31.4%) by adding salts of chlorides, sulphates and bicarbonates (6:3:1) of sodium and calcium (4:1) and different ECe levels actually attained after equilibrium were 0.7, 4.2, 8.1, 16.3 and 32.5 dS m^{-1}. A polythene lining was provided inside the pots and suitable arrangement was made to add water to the pots from the top and bottom alternatively. Each treatment was replicated three times. Nine months old seedlings of *Pongamia pinnata* raised in nursery were transplanted in the pots on November 25, 1979. Irrigation with deionized water was given as and when required during the entire growth period of about 22 months. Observations on height and girth of each plant were recorded regularly at an interval of three months.

In the other experiment, ESP levels were created artificially in the above mentioned normal silty clay loam soil by addition of varying amounts on Na HCO_3 (Bains and Fireman, 1964). Different levels of ESP actually attained in the experiment were 1.1, 15.2, 30.6, 61.4 and 88.7. Replication of treatments, time of transplanting, recording of observations and other details were the same as described in the salinity experiment.

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At the termination of experiments, the whole plant was uprooted from the pots, washed thoroughly with distilled water and dried in the air. Observations on average fresh weight and oven dry weight of plants in each treatment were made. After cutting and grinding, the plant samples were wet digested and Na^+ and K^+ were determined flame photometrically and Ca^{++} and Mg^{++} on Baird Atomic Absorption Spectrophotometer.

Results and Discussion

Growth Response : Data on periodic measurements of height and girth of plants reveal that *Pongamia pinnata* failed to grow at ECe 32.5 dS m^{-1} and ESP at and above 30.6. Hence the data in Table 1 and Fig. 1 are reported only in respect of ECe upto 16.3 dS m^{-1} and ESP upto 15.2 levels. These observations indicate that *Pongamia pinnata* can tolerate a fair degree of salinity (ECe about 16 dS m^{-1}) and low levels of sodicity (ESP about 15). The trends in growth as a function of time indicated fast growth from June to September 1980, slow growth from Sept. 1980 to June 1981 and again fast growth from June to September 1981. It shows that the period from June to September is the period of maximum growth of *Pongamia pinnata*.

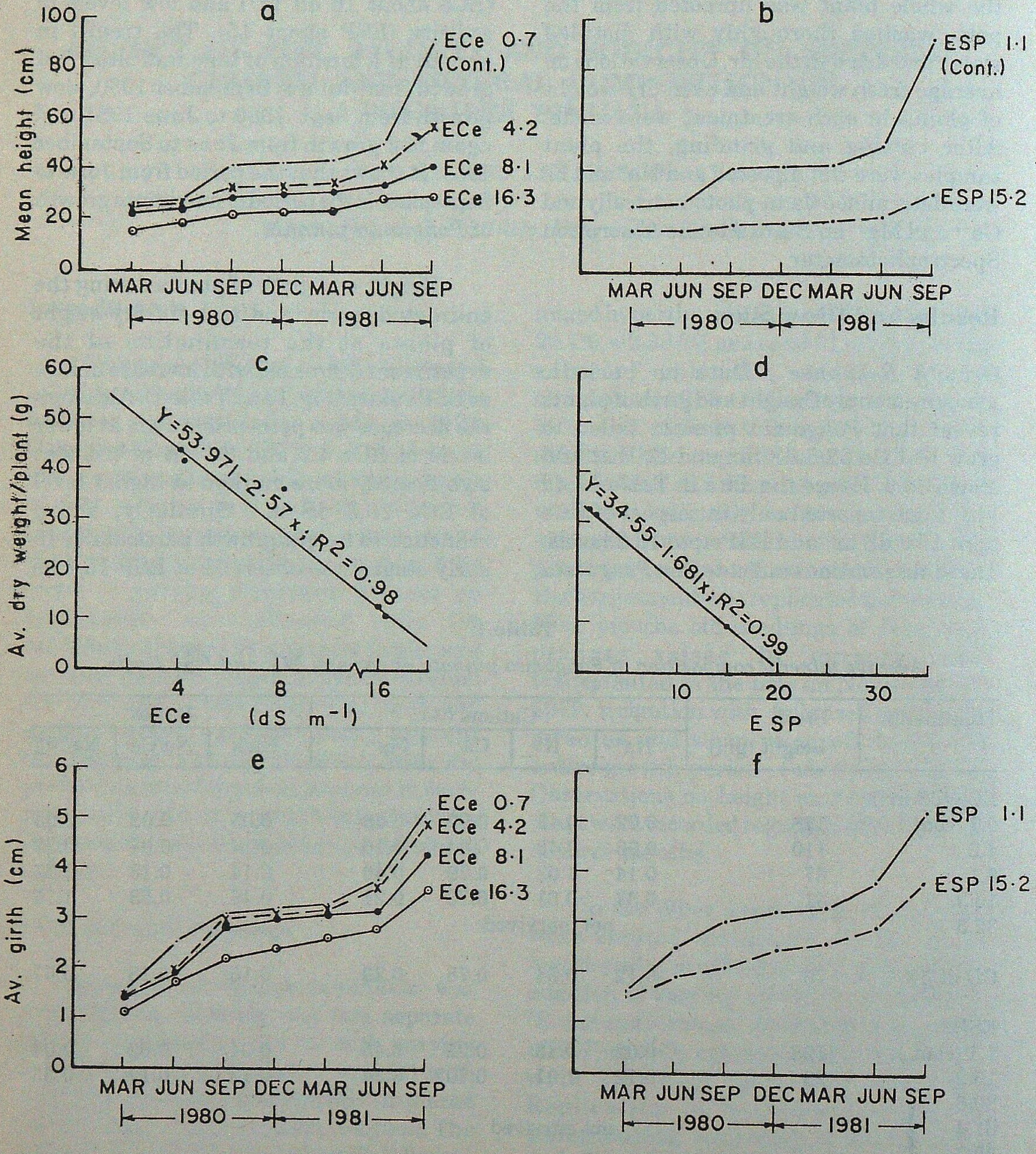
Height and girth of plants during the entire study period and fresh and dry weight of plants at the termination of the experiment decreased with increase in ECe or ESP values (Fig. 1 and Table 1). Although the decrease was perceptible even at lower levels of ECe 4.2 and 8.1 dS m^{-1}, it was significantly more marked at higher level of ECe 16.3 dS m^{-1}. Similarly, sharp reduction in height growth particularly in early stages was observed at ESP 15.2 as

Table 1

Average mineral composition of Pongamia pinnata at varying ECe and ESP levels

Treatments	Fresh weight (gm)	Cations (%)				Ratios		
		Na^+	K^+	Ca^{++}	Mg^{++}	Na/k	Na/Ca	Na/Mg
ECe (dS m^{-1})								
0.7 (cont.)	128	0.02	0.43	0.92	0.45	0.05	0.02	0.04
4.2	110	0.06	0.43	0.84	0.16	0.14	0.07	0.37
8.1	67	0.14	1.02	0.79	0.40	0.14	0.18	0.35
16.3	31	0.37	0.81	0.70	0.21	0.46	0.53	1.76
32.5		not survived						
CD at 5%	76	0.12	0.64	0.78	0.29	0.16	0.18	0.57
ESP								
1.1 (cont.)	128	0.02	0.43	0.92	0.45	0.04	0.02	0.04
15.2	23	0.12	1.01	0.70	0.34	0.12	0.17	0.35
30.6 61.4 88.7		not survived						
CD at 5%	67	0.05	0.68	0.76	0.38	0.06	0.07	0.18

Fig. 1



Average height, dry matter yield and girth of *Pongamia pinnata* at varying salinity (ECe) and ESP levels compared to control. The critical limits of soil salinity and alkali tolerance of this species corresponding to 50 per cent reduction in height growth as a function of ECe ($Y = 43.73 - 1.4154x$; $R^2 = 0.3$) and ESP ($Y = 47.85 - 1.814x$; $R^2 = 0.4$) were calculated at ECe 14.7 dS m^{-1} and ESP 15. The dry weight per plant in case of soil salinity showed relatively a gentle slope with increasing values of ECe upto 16.3 dS m^{-1}. Steep slope in case of ESP is indicative of lower tolerance of *Pongamia pinnata* to soil sodicity. Taking control as 100, *Pongamia pinnata* showed about 69%, 79%, 76% and 79% at ECe 16.3 dS m^{-1} and 67%, 31%, 82% and 83% reduction at ESP 15.2 in height, girth, fresh weight and dry weight, respectively. The best fit curves of salinity and ESP related to dry weight of plants given in Figs. 1c and 1d indicated 50 per cent reduction in dry weight at ECe around 11 dS m^{-1} and ESP 10.8. Almost similar trends of reduction in fresh weight of plants were observed in saline and sodic soils. These results indicated that biomass production was reduced at higher levels of ECe or ESP.

Mineral composition : The data on plant analysis in Table 1 indicated that the uptake of sodium increased with ECe or ESP, but the rate of increase in Na^+ uptake was comparatively more marked in case of sodic as compared to saline conditions. The increase in sodium uptake showed a fair correlation with the reduction in height growth, girth, fresh and dry weight of *Pongamia pinnata*. Regression function between height growth and Na content in foliage was computed in saline ($Y = 76.74 - 145.68x$; $R^2 = 0.68$) and sodic soils ($Y = 105.4 - 620x$; $R^2 = 0.99$). The critical concentrations corresponding to 50 per cent reduction in growth indicated 0.21 per cent Na^+ in foliage under saline and 0.10% Na in foliage under sodic soil conditions. Taking Na^+ concentration as 100 in control, the increase was more pronounced at higher levels of ESP as compared to higher levels of ECe. High absorption of Na^+ seems to impart adverse effect on plant growth.

The uptake of calcium in plants showed a decreasing trend with increasing in soil salinity and sodicity levels. About 24% decrease at ESP 15.2 and almost the same percentage at ECe 16.3 dS m^{-1} was recorded as compared with the controls. Lower uptake of calcium due to high exchangeable Na in salt affected soils appeared to augment the adverse effect of sodium on plant growth.

Concentration of K^+ and Mg^{++} in *Pongamia pinnata* did not have any definite relationship with increase in ECe or ESP. However, an abrupt increase in K^+ content and lower values of Mg^{++} were observed at ESP 15.2 as compared to controls. These data suggest that this tree species also shows differential uptake of cations under salt affected conditions like agricultural crops as reported by Brown and Hayward (1956). Shalhevet and Bernstein (1968) and Heikal (1977). Owing to higher uptake of sodium Na/K, Na/Ca and Na/Mg ratios increased with increase in salinity or sodicity. Apparently, the increase in values of these ratios, depended more upon the increase of sodium content, rather than the reduction in the content of calcium, magnesium and potassium.

Acknowledgement

Authors are grateful to the Director, Forest Research Institute, Dehra Dun, for his keen interest in the study and providing laboratory facilities.

SUMMARY

Performance of *Pongamia pinnata* was evaluated under pot culture conditions at artificially created varying salinity (ECe) levels of 0.7, 4.2, 8.1, 16.3 and 32.5 dS m^{-1} and exchangeable sodium percentage (ESP) levels of 1.1, 15.2, 30.6, 61.4 and 88.7 in an alluvial silty clay loam soil (Fine-loamy mixed hyperthermic Typic Ustochrept) by addition of different salts. *Pongamia pinnata* failed to grow at a level of ECe 32.5 dS m^{-1} and ESP at and above 30.6. Height, girth, fresh weight and dry weight of uprooted plants at the time of termination of experiment were found to have decreased with increase in ECe or ESP. Uptake of Na^+ by plants increased progressively with increase in ECe or ESP levels, while the uptake of Ca^{++} decreased and Mg^+ and K^+ did not exhibit any definite relationship with increase in salinity or sodicity conditions. The values of Na/K, Na/Ca and Na/Mg ratios in plants increased with increase in ECe or ESP. Relatively lower uptake of Ca^{++} due to high concentration of exchangeable Na^+ appeared to increase the adverse effect of sodium on plant growth in saline and sodic soils.

पोंगामिया पिन्नाटा के पौधों की बढ़वार और खनिजीय गठन पर मृदा की क्षारीयता और सोडीयता का प्रभाव

के० सिंह व जे०एस०पी० यादव

सारांश

गमलों में उगाने वाली दशाओं और जलोढ़ सादमयी चिकनी दुमट मृदा (महीन उन्मृद मिली हाइपरथर्मिक टिपिक उस्टोक्रेप्ट) में विभिन्न लवण मिलाकर कृत्रिमतः बनाई विभिन्न क्षारयीता (ECe) के भिन्न-भिन्न यथा 0.7, 4.2, 8.1, 16.3 और 32.5 dsm^{-1} स्तरों तथा विभिन्न विनिमेय सोडियम प्रतिशतों यथा 1.1, 15.2, 30.6, 61.4,और 88.7 वाली मृदा में *पोंगामिया पिन्नाटा* की क्रियाशीलता का मूल्यांकन किया गया । ECe 32.5 dsm^{-1} और विनिमेय सोडीयता प्रतिशत् 30.6 और इससे अधिक रहने पर *पोंगामिया पिन्नाटा* अंकुरित ही नहीं हो पाई । सपंरीक्षण पूरा होने पर उखाडे गए पौधों की ऊंचाई, गोलाई, ताजा भार और शुष्क भार ECe या विनिमेय सोडियता प्रतिशत बढ़ने पर घटते पाए गए । ECe या विनिमेय सोडीयता प्रतिशत् क्रमशः बढ़ते जाने पर सोडियम का उद्ग्रहण पौधों में बढा किन्तु कैलशियम का उद्ग्रहण घटा परन्तु पोटाशियम के उद्ग्रहण का क्षारीयता या सोडीयता बढ़ने के साथ कोई निश्चित संबन्ध रहता प्रदर्शित नहीं हुआ । ECe और विनिमेय सोडीयता प्रतिशत् बढ़ने के साथ पौधों के सोडियम / पोटाशियम, सोडियम / कैलशियम और सोडियम / मैगनीशियम अनुपात में वृद्धि हुई । कैलशियम का अपेक्षतया कम उद्ग्रहण, जो विनिमेय सोडियम के अधिक जमाव होने के कारण है, पौधों की क्षारीय और सोडीय मृदाओं में बढ़वार पर कुप्रभाव डालने में वृद्धि करता प्रतीत हुआ ।

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REGENERATION STATUS OF AN OAK FOREST OF GARHWAL HIMALAYA

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Introduction

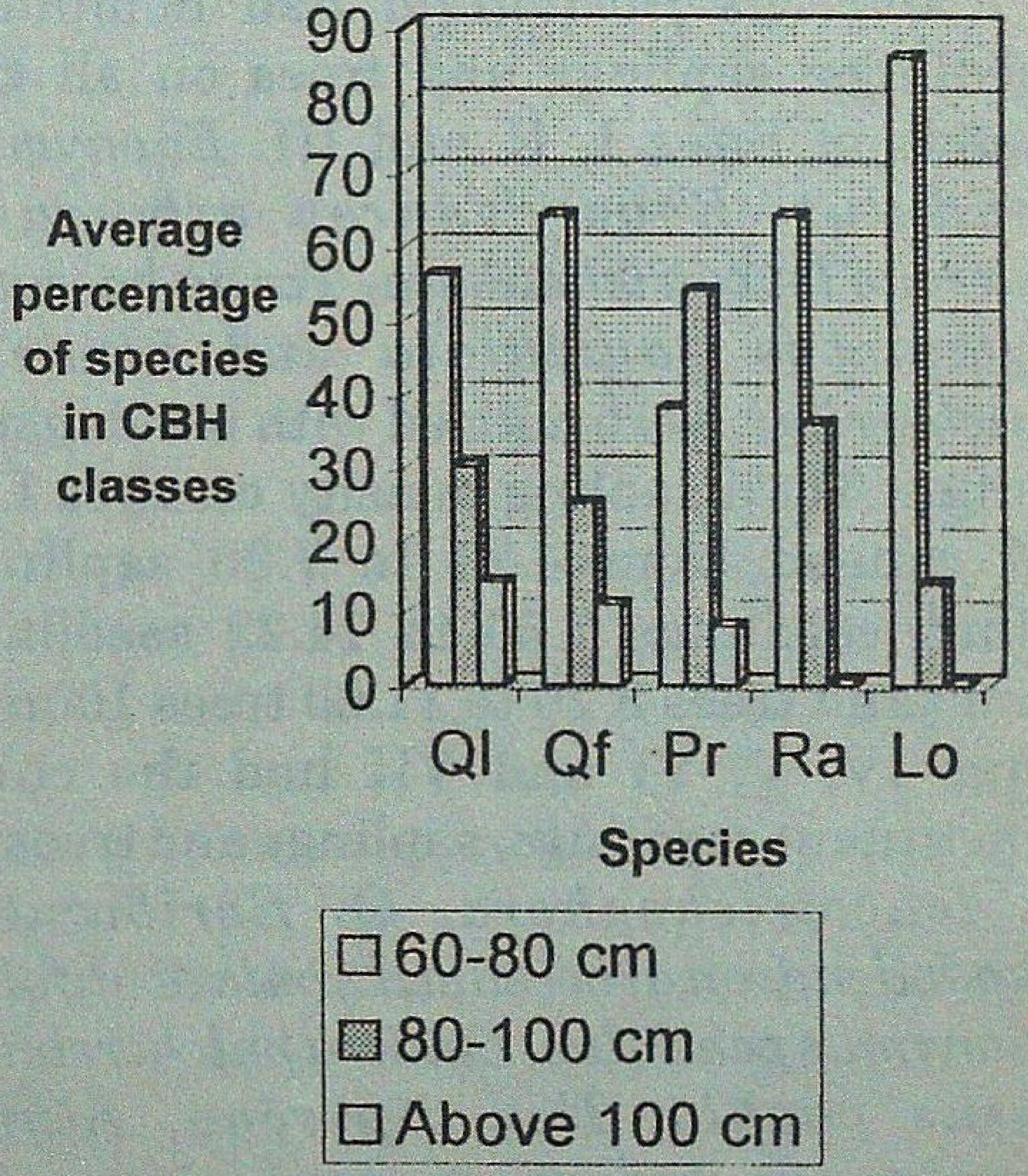
Human impacts on natural ecosystem are causing changes in their composition and stability. Regeneration potential of a species is simply expressed as its ability to complete the life cycle. The age distribution in the population is the result of both natality and mortality. The ratio of various age groups in a population determines the reproductive status of the population and indicates the future course (Odum, 1971). This is also true for the forest communities (Hartshorn, 1972, 1975; Knight, 1975). In temperate communities it has often been seen that the species having smaller percentage of young individuals are not replaced by others having greater younger population (McIntosh, 1980). The present paper deals with the structure of the trees, seedlings and saplings to understand the regeneration status on 10 sites of a temperate forest of the Garhwal Himalaya.

Materials and Methods

The study sites are situated at 30° N latitude and 78°E longitude. The study area ranged in elevation for different stands of each site as 1800 to 2000 m hill base stand, 2000 to 2200 m for hill slope stand, and 2200 to 2400 m for hill top stand. The rainfall was highest in August and the total rainfall for the study months (June 1993 to June 1994) was 2006 mm.

The seedlings and saplings of tree species were distinguished on the basis of height and diameter of these individuals. The seedlings (<30 cm height), saplings (>30 cm height and <30 cm circumference) and trees (>30 cm circumference) were

Fig. 1



Ql = *Quercus leucotrichophora*; Qf = *Quercus floribunda*; Pr = *Pinus roxburghii*; Ra = *Rhododendron arboreum*; Lo = *Lyonia ovalifolia*

Average percentage of trees of dominant species in CBH Classes

Table 1

Average percentage of trees of dominant species in CBH (Circumference at Breast Height) classes in the study area

Species	Average percentage of species in CBH classes		
	60-80 cm	80-100 cm	Above 100 cm
Quercus leucotrichophora	56	30	14
Q. floribunda	64	25	11
Pinus roxburghii	38	54	8
Rhododendron arboreum	64	36	—
Lyonia ovalifolia	86	14	—

classified following the measurements given by Mueller-Dombois and Ellenberg (1974). For seedlings and saplings 40 quadrats of 5 x 5 m each and for trees 10 quadrats of 10 x 10 m each were selected to estimate the density values.

Results

Quercus floribunda had dominant seedlings, saplings and trees on all the stands of Sites I, II and III. *Euonymus pendulus, Rhododendron arboreum, Quercus leucotrichophora, Taxus baccata, Symplocos paniculata* and *Lindera pulcherrima* were noticed with low density values. Total sapling density on sites I to III ranged from 4.21 to 7.90 saplings 25m^{-2}, seedlings 7.60 to 14.22 seedlings 25m^{-2} and trees 8.20 to 11.60 trees 100m^{-2}. Sites IV, V, VI and VII had the chief constituent seedlings, saplings and trees of *Q. leucotrichophora, Q. floribunda, Rhododendron arboreum, Lyonia ovalifolia Euonymus pendulus, Lindera pulcherrima, Pyrus pashia, Ilex dipyrena, Alnus nepalensis, Symplocos paniculata* and *Pinus roxburghii*. Total sapling density for these four sites ranged from 3.84 to 7.73 saplings 25m^{-2}, and seedling density from 7.70 to 12.41 seedlings 25m^{-2} and tree density from 6.30 to 11.40 trees 100m^{-2}.

Sites VIII, IX and X had almost the similar species as reported in the preceding paragraph. On these sites *Quercus leucotrichophora* and *Pinus roxburghii* were major constituents of the growing individuals. Total sapling density on these three sites ranged from 2.64 to 7.31 samplings 25 m^{-2} and seedlings 5.83 to 14.21 seedlings 25 m^{-2} and trees 6.70 to 11.70 trees 100 m^{-2} (Table 2).

The average percentage distribution of trees in major CBH (circumference at breast height) classes for the study area is given in Table 1 and Fig. 1.

Most of the species in sapling and seedling layers exhibited contiguous pattern of distribution and remaining species were randomly distributed. Regular distribution was not exhibited by the seedling and sapling of any species.

Discussion

Among 15 species, 88% of tree species were represented by their seedlings, while the sapling percentage was further reduced. Some of the species were not observed in seedling stage.

Table 2

Density (individuals/25 m^2) and percentage (%) values of seedlings, saplings and trees

Site	Species	Seedlings		Species	Saplings		Species	Trees	
		(%)	Indiv./ $25m^2$		(%)	Indv./ $25m^2$		(%)	Indv./ $25m^2$
1	2	3	4	5	6	7	8	9	10
Site I :									
HT	Qf	67.79	7.85	Qf	57.16	3.95	Qf	55.17	4.80
	Tb	10.53	1.22	Ep	22.43	1.55	Ra	24.14	2.10
	Others	21.67	2.51	Others	20.40	1.41	Others	20.69	1.80
HS	Qf	58.84	7.32	Qf	47.51	2.00	Qf	43.75	4.20
	Ra	14.07	1.75	Ra	17.81	0.75	Ra	22.92	2.20
	Others	27.09	3.37	Others	34.68	1.46	Others	33.33	3.20
HB	Qf	45.34	5.25	Qf	55.89	2.80	Qf	28.45	3.30
	Lp	14.42	1.67	Ql	21.36	1.07	Ql	25.00	2.90
	Others	40.24	4.66	Others	22.75	1.14	Others	46.55	5.40
Site II :									
HT	Qf	61.36	7.10	Qf	49.88	2.15	Qf	38.46	4.00
	Ra	11.24	1.30	Ep	24.83	1.07	Ra	17.31	1.80
	Others	27.40	3.17	Others	25.29	1.09	Others	44.23	4.60
HS	Qf	76.97	5.85	Qf	40.06	3.22	Qf	51.04	4.90
	Ra	16.05	1.22	Ra	25.95	2.05	Ql	11.56	1.10
	Others	7.50	0.57	Others	33.29	2.63	Others	37.50	3.60
HB	Qf	44.90	5.02	Qf	42.79	2.70	Qf	37.65	3.20
	Ql	23.70	2.65	Ql	22.19	1.40	Ql	24.70	2.10
	Others	31.39	3.51	Others	35.02	2.21	Others	37.65	3.20
Site III :									
HT	Qf	39.73	5.65	Qf	40.46	2.25	Qf	43.90	3.60
	Ql	34.56	4.90	Ql	36.33	2.02	Ra	19.51	1.60
	Others	25.81	3.67	Others	23.20	1.29	Others	36.58	3.00
HS	Qf	54.69	7.40	Qf	51.66	2.95	Qf	44.83	3.90
	Ql	20.10	2.72	Ql	25.74	1.47	Ra	22.99	2.00
	Others	25.20	3.41	Others	22.59	1.29	Others	32.18	2.80
HB	Ql	47.38	5.97	Qf	41.80	2.65	Qf	46.74	4.30
	Qf	33.49	4.22	Ql	27.60	1.75	Ra	16.30	1.50
	Others	19.13	2.41	Others	30.60	1.94	Others	39.96	3.40
Site IV :									
HT	Ql	75.84	8.60	Ql	64.88	3.40	Ql	42.00	4.20
	Qf	9.70	1.10	Qf	15.27	0.80	Ra	22.00	2.20
	Others	14.46	1.64	Others	19.84	1.04	Others	36.00	3.60
HS	Ql	72.60	7.10	Ql	57.83	3.47	Ql	36.73	3.60
	Ra	8.18	0.80	Ra	12.00	0.72	Ra	16.33	1.60
	Others	19.22	1.88	Others	30.07	1.81	Others	46.94	4.60

(Contd...)

1	2	3	4	5	6	7	8	9	10
HB	Ql	69.09	5.32	Ql	53.39	2.60	Ql	52.13	4.90
	Lo	11.95	0.92	Lo	18.48	0.90	Ra	22.34	2.10
	Others	18.96	1.46	Others	28.13	1.37	Others	25.53	2.40
Site V :									
HT	Ql	77.45	7.90	Ql	78.61	5.22	Ql	40.91	3.60
	Lo	10.78	1.10	Ra	10.84	0.72	Ra	29.54	2.60
	Others	11.76	1.20	Others	10.54	0.70	Others	29.54	2.60
HS	Ql	70.07	7.07	Ql	75.98	4.65	Ql	46.15	4.20
	Ra	16.35	1.65	Ra	11.44	0.70	Lo	28.57	2.60
	Others	13.58	1.37	Others	12.58	0.77	Others	25.27	2.30
HB	Ql	69.79	6.40	Ql	71.56	4.00	Ql	41.27	2.60
	Ra	17.45	1.60	Lo	13.77	0.77	Ra	22.22	1.40
	Others	12.76	1.17	Others	14.67	0.82	Others	36.51	2.30
Site VI :									
HT	Ql	63.60	7.55	Ql	69.19	2.65	Ql	53.41	4.70
	Qf	18.11	2.15	Ra	14.36	0.55	Ra	28.41	2.50
	Others	18.28	2.17	Others	16.71	0.64	Others	18.18	1.60
HS	Ql	68.49	8.50	Ql	54.98	4.25	Ql	65.75	4.80
	Qf	21.92	2.72	Qf	21.60	1.67	Ra	13.70	1.00
	Others	9.59	1.19	Others	23.41	1.81	Others	20.55	1.50
HB	Ql	65.62	7.10	Ql	72.50	4.22	Ql	41.67	3.00
	Qf	16.17	1.75	Ra	72.50	4.22	Ra	41.67	3.00
	Others	18.21	1.97	Others	11.68	0.68	Others	16.66	1.20
Site VII :									
HT	Ql	59.50	6.67	Ql	61.07	3.20	Ql	37.18	2.90
	Ra	18.46	2.07	Ra	12.40	0.65	Lo	29.49	2.30
	Others	22.03	2.47	Others	26.53	1.39	Others	33.33	2.60
HS	Ql	53.19	5.75	Ql	56.20	2.22	Ql	45.61	5.20
	Ra	22.39	2.42	Lo	16.45	0.65	Lo	32.46	3.70
	Others	24.42	2.64	Others	27.34	1.08	others	21.93	2.50
HB	Ql	69.29	7.65	Ql	57.28	2.40	Ql	36.11	2.60
	Ra	14.04	1.55	Lo	13.12	0.55	Lo	31.94	2.30
	Others	16.67	1.84	Others	29.59	1.24	Others	31.94	2.30
Site VIII :									
HT	Ql	58.42	3.40	Ql	60.65	2.22	Ql	62.49	4.20
	Pr	15.46	0.90	Pr	16.39	0.60	Ra	14.92	1.00
	Others	26.12	1.52	Others	22.95	0.84	Others	22.39	1.50
HS	Ql	57.35	5.07	Ql	40.53	1.07	Ql	36.73	3.60
	Pr	19.23	1.70	Pr	35.98	0.95	Pr	30.61	3.00
	Others	23.42	2.07	Others	23.48	0.62	Others	32.65	3.20

(Contd...)

1	2	3	4	5	6	7	8	9	10
HB	Ql	41.89	3.02	Ql	41.74	1.82	Pr	36.56	3.40
	Pr	28.43	2.05	Pr	35.55	1.55	Ql	31.18	2.90
	Others	29.68	2.14	Others	22.71	0.99	Others	32.26	3.00
Site IX :									
HT	Ql	56.93	7.15	Ql	71.43	3.40	Ql	40.00	3.60
	Lo	15.12	1.90	Ra	14.07	0.61	Ra	20.00	1.80
	Others	27.94	3.51	Others	14.49	0.69	Others	40.00	3.60
HS	Ql	55.78	7.87	Ql	72.78	5.32	Ql	29.91	3.50
	Pr	15.24	2.15	Ra	9.85	0.72	Pr	25.64	3.00
	Others	28.99	4.09	Others	17.37	1.27	Others	44.44	5.20
HB	Ql	52.75	5.27	Ql	47.67	2.35	Pr	43.14	4.40
	Ra	20.52	2.05	Pr	24.75	1.22	Ql	35.29	3.60
	Others	26.73	2.67	Others	25.79	1.36	Others	21.57	2.20
Site X :									
HT	Ql	55.47	5.22	Ql	72.87	3.25	Ra	34.04	3.20
	Ra	24.65	2.32	Pr	11.21	0.50	Ql	30.85	2.90
	Others	19.87	1.87	Others	15.92	0.71	Others	35.11	3.30
HS	Ql	63.69	9.05	Ql	43.44	2.32	Pr	28.97	3.10
	Pr	17.14	2.72	Pr	26.22	1.40	Ql	24.30	2.60
	Others	17.38	2.47	Others	30.34	1.62	Others	46.73	5.00
HB	Ql	41.36	4.07	Ql	48.09	2.65	Pr	39.79	3.90
	Ra	25.91	2.55	Pr	31.22	1.74	Ql	26.53	2.60
	Others	32.72	3.22	Others	20.69	1.14	Others	33.67	3.30

HT = Hill Top, HS = Hill Slope, HB = Hill Base, Ql = *Quercus leucotrichophora*, Qf = *Quercus floribunda*, Ra = *Rhododendron arboreum*, Lo = *Lyonia ovalifolia*, Ep = *Euonymus pendulus*, Tb = *Taxus baccata*, Pr = *Pinus roxburghii*, Lp = *Lindera pulcherrima*.

The cause of regeneration failure in these forests may be even-aged population structure and adverse effects. Once the even-aged population of trees is established, it is difficult for new age class to enter the canopy until that population dies from accident, disease or age (Harper, 1977). In these forests, transfer of seedling to sapling stage was comparatively restricted or negligible as also reported by Rao (1984) in another study.

The presence of good regeneration potential shows suitability of species. Low values of sapling and seedling density indicate a low regeneration potential of a species. The climatic factors and biotic stress influence the regeneration of species comprising the vegetation. Abrams (1992) discussed effects of fire on regeneration of oak forest and Attiwill (1994) described disturbance, conservation and management of forest ecosystems. The population of different temperate and tropical forest species have been studied by a number of workers in different parts of Himalaya (Singh *et al.*, 1984; Singh 1986; Yadava and Singh, 1988; Negi *et al.*, 1992; Rao, 1994). In a floodplain, regeneration studies were carried out by Jones (1994). Rajesh *et al.* (1996) observed regeneration characteristics of different evergreen forests of Kerala.

Higher seedling density values were reduced to sapling stage due to biotic disturbance and competition for space and nutrition. The nearby inhabitants affect the sapling and seedling population of different species. The oak forests are important formations in the Himalaya and these forests are related with water level in these areas. The higher percentage of seedlings was supported by phenological adaptation of oak due to better seedling establishment by reduced litter layer, establishment of thick litter cover protecting seeds from monkeys, and massive litter fall after seed fall (Singh *et al.*, 1990).

In a study on a temperate forest of the Himalaya, Singh *et al.* (1984) reported that the pine forests are replacing the oak forests which is affecting the nitrogen cycle in these areas. In comparison to pine forest, oak forest is non-inflammable but causes sufficient loss, the fire that usually spreads in the pine forests which are located just below the oak forests. In broad-leaved forests the disturbance gives an opportunity for invasion by conifers and if the disturbance is prolonged, the oak and other broad-leaved forests get slowly replaced by pine forests in the lower fringes. There are possibilities that this process may revert back to the original composition if the disturbance is reduced. In general, the pine forests act as primary colonisers and the climax formation in such forests takes place as a result of fire.

The study Sites I, II and III showed highest seedling and sapling density values for *Quercus floribunda* with an expanding population structure, which indicated that *Q. floribunda* would be dominated in those forests in future with its associates *Euonymus pendulus, Lindera pulcherrima, Q. leucotrichophora* and *Lyonia ovalifolia*. Sites IV, V, VI and VII will be dominated by *Q. leucotrichophora* in future with *L. ovalifolia, Rhododendron arboreum* and *Q. floribunda*. In such regenerating forests, the population distribution pattern shows inverse 'J' shaped structure.

Sites VIII, IX and X showed an association of *Q. leucotrichophora* and *Pinus roxburghii* and were subjected to biotic pressure. On such sites *P. roxburghii* may dominate in the future on the basis of its seedling and sapling density at present. Some of the forest stands were dominated by *P. roxburghii* at present. In most of the oak forests, Singh and Singh (1992) have pointed out that the exploitation of young individuals by villagers has resulted in a population structure showing declining trend.

Interestingly, *P. roxburghii* is known to be the most actively regenerating species of the region (Dwivedi and Mathur, 1978), whereas it is not regenerating actively on *Pinus* dominated stands of the present study. Shade and relatively thicker litter layer may act as limiting factor for the regeneration, for seeds are not large enough to supply food to growing seedlings for long (Rao and Singh, 1985). The active regeneration of pine over large area in the Central Himalaya is largely affected because of bio-edaphic disturbances and management practices (Singh *et al.*, 1984). The species is of ruderal type (Grime, 1977; Rao and Singh, 1985) and appears to fail competing with last successional, 'competitive type' of species as long as disturbance is in check. In the present study, *Pinus roxburghii* dominated the sites which had low altitude. The hill top, hill slope and hill base stands in each study site showed a decreasing altitude respectively and similarly variations in the sub-dominant species

SUMMARY

The density of seedlings and saplings, a measure of regeneration potential, was studied for ten forest sites with three stands each consisting of three elevational forest types : *Quercus leucotrichophora-Pinus roxburghii* (1800-2000m), *Q. leucotrichophora* (2000-2200m) and *Q. floribunda* (2200-2400m). In these forests the sapling density ranged from 2.64 to 7.73 saplings 25 m^{-2}, and seedling density 5.28 to 14.52 seedlings 25 m^{-2}. On the basis of regeneration potential, Sites I to III were dominated by *Q. floribunda*, Sites IV to VIII and X by *Q. leucotrichophora* and Site IX by *Pinus roxburghii*. Most of the species were contiguously distributed. Only 88% of the tree species were recorded in seedling stage while sapling percentage is further reduced.

गढ़वाल में हिमालय प्रदेश के बांज वन की पुर्नजनन स्थिति

जी० एस० रैवार, मनोज धौलाखण्डी व प्रमोद कुमार

सारांश

बीजांकुरों और बाल वृक्षों की सघनता का, जो पुनर्जनन क्षमता का माप होते हैं, अध्ययन 10 वन स्थलियों में जहॉं तीन भिन्न-भिन्न ऊंचाईयों वाले वन प्ररूप लगे हुए थे - *क्वेरकस ल्यूकोट्राइकोफोरा-पाइनस राक्सबर्घिआई-* (1800-2000 मी०), *क्वे० ल्यूकोट्राइकोफोरा* (2000-2200 मी०) और *क्वे० फ्लोरिबण्डा* (2200-2400 मी०) किया गया । इन वनों में बाल वृक्षों का घनत्व 2.64 से 7.73 बाल वृक्ष प्रति 25 वर्ग मी० तथा बीजांकुरों का घनत्व 5.28 से 14.52 बीजांकुर प्रति 25 वर्ग मी0 पाया गया । पुनर्जनन क्षमता के आधार पर स्थल I से III में *क्वेरकस फ्लोरिबंडा* की अधिरोहिता तथा स्थल IV से VIII और X में *क्वे० ल्यूकोट्राइकोफोरा* की तथा स्थल IX में *पाइनस राक्सबर्घिआई* की अधिरोहिता पाई गई । अधिकांश जातियों के वितरण एक दूसरे से भिडे हुए थे । वृक्ष जातियों का केवल 88% बीजांकुर अवस्था में पाया गया तथा बाल वृक्षों का प्रतिशत् इससे भी कम पाया गया ।

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EFFECT OF PHYTOHORMONE GIBBERELLIC ACID (GA_3) ON THE GERMINATION, GROWTH AND BIOMASS PRODUCTION OF *PERSEA BOMBYCINA*

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Introduction

Persea bombycina King ex Hook (*Machilus bombycina* King ex Hook. f) belongs to the family Lauraceae. It is a middle-sized tree with spreading branches. It is the main host plant of Muga Silkworms. The golden yellow Mugasilk produced by the silkworm, is the pride of Assam. More than 2,00,000 people of Assam are now engaged in the production of this particular type of silk and silk products. Assam continues to be the main production centre of this rare silk, followed by Meghalaya.

The availability of the host plant in Arunachal Pradesh, Mizoram and Nagaland and the salubrious climate for rearing Muga Silkworms in these places show great potential for exploitation of the overall production of Muga silk.

However, raw Muga silk production has dropped from 70 metric tonnes, in 1973-74 to 55 metric tonnes in 1984-85. Various reasons have been shown for possible causes of such a development (Samson, 1986). One of the causes was that *P. bombycina* seeds show slow and erratic germination, thereby bringing down the population. Under natural conditions, it takes about 3-4 years for establishment of a plant and commencing of Muga rearing.

It has been reported that Gibberellic Acid (GA_3) promotes germination and enhances vegetative growth of many species (Sarma and Barman, 1972-74; Sarma and Chakraborty, 1975, 1977; Misra and Sarma, 1981).

Under the circumstances, it was considered pertinent to find the efficacy of gibberellic acid on germination growth and biomass production of *P. bombycina*.

Material and Methods

Seeds of *P. bombycina* (King ex Hook) were collected from RMRS, Mirza, Assam on 15th May, 1994.

The collected seeds were washed in water to remove the pulp. The seeds were treated with 1% mercuric chloride solution and then thoroughly washed in water, dried for a day in sunlight. Then the seeds were stored under room temperature of 2 days. GA_3 was applied at the concentrations of 0, 1, 10, 100, 250, 500 and 1000 ppm. Seeds 50 in number were soaked in respective concentrations of GA_3 in Petri dishes for 24 hrs. Then the seeds were planted in Polythene bags containing sterilized sand. The experiment was replicated three times.

The percentage of germination was recorded from fourth week of sowing the seeds and was continued upto 45 days. The height of the plants was recorded after 90 days. To study the biomass, the plants were uprooted after 3 months and the roots were washed under tap-water. Water was removed from the roots by gently pressing with blotting paper. The shoot portion was separated from the root by cutting with a sharp razor. Fresh and dry weight of shoots and roots at the various strengths of GA_3 was recorded. Average weight was calculated separately and then added to obtain the fresh biomass of the seedlings at the respective strengths. Similarly dry weight and dry biomass were recorded (Table 1).

Results and Discussion

The data in Table 1 reveals that the seeds soaked in 500 ppm of GA_3 solution recorded the highest percentage of germination (68%) after 29 days of sowing as against 38% at control after 45 days. This is in conformity with the earlier reports (Thangavelu *et al.*, 1984-85). Also there was marked difference between the average number of leaves, highest being in 100 ppm (12 leaves) followed by 10 ppm (11 leaves). In case of biomass the average fresh weight of the seedlings was highest in 10 ppm and average dry weight in 100 ppm. The seed soaked in gibberellic acid irrespective of their concentration, took 27-32 days to commence germination as against 45 days in control.

As a result gibberellic acid helped in enhancing the germination and reducing the period of germination of *P. bombycina* seeds.

Although, the percentage of germination and height of the seedling were highest at 500 ppm and the fresh biomass yield was highest at 10 ppm, however on dry weight basis it was highest at 100 ppm. This can be attributed to more metabolic activities at lower concentrations resulting in more dry matter accumulation.

Table 1

Effect of Gibberellic Acid (GA_3) on seed germination, seedling growth and biomass of Persea bombycina

Treatment GA_3 (ppm)	Germination (days)	Percentage of Germination	Av. Ht. of seedling	Av. No. of leaves/ seedling	Biomass					
					Average Fresh Weight (mg)			Average Dry Weight (mg)		
					Shoot	Root	Total Biomass	Shoot	Root	Total Biomass
1000	27	64	14.0	5	162.00	67.33	229.22	25.66	9.00	34.66
500	29	68	16.0	6	240.33	69.33	309.66	38.00	8.66	46.66
250	30	56	14.5	10	293.66	196.33	489.99	51.00	11.66	62.66
100	30	52	14.0	12	252.33	425.66	677.99	114.00	35.66	149.66
10	31	48	14.0	11	791.60	561.80	1353.40	55.00	14.00	69.00
1	32	44	12.0	6	500.00	258.00	758.00	38.00	12.33	50.33
0	45	38	10.0	5	299.00	98.00	397.00	37.00	9.66	46.56

SUMMARY

The paper presents the results of investigation carried out at the Botany Department, Gauhati University to find the effect of Gibberellic Acid, in various strengths, on the germination, growth and biomass of *P. bombycina*. GA_3 at higher concentration enhanced germination rapidly, whereas the biomass yield was higher at lower concentrations.

पादप होर्मान जिबेरेलिक अम्ल का *पर्सिआ बोम्बीसिना* के अंकुरण, बढ़वार और जैवपुंज उत्पादन पर प्रभाव

स्वपना दत्त हजारिका व सी०एम० शर्मा

सारांश

इस अभिपत्र में *प० बोम्बीसिना* के अकुंरण, बढ़वार और जैवपुंज पर विभिन्न शक्तियों जिबेरेलिक अम्ल देने का प्रभाव मालूम करने के लिए गुआहाटी विश्वविद्यालय के वनस्पति विभाग में किए गए अन्वेषणों का परिणाम प्रस्तुत किया गया है । जीए$_3$ अधिक संकेन्द्रणों में देने पर अंकुरण में तीव्रता से वृद्धि हुई किन्तु जैवपुंज की अधिक प्राप्ति उसको कम शक्ति संकेन्द्रणों में देने पर ही मिली ।

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RESEARCH NOTES
(I)

PODAXIS PISTILLARIS (L : PERS.) FR. - AN ADDITION TO THE LIST OF FUNGI OF RAJASTHAN (INDIA)

Introduction

During a mycological excursion in September 1997 in the State of Rajasthan the author collected some interesting fungi from Jaisalmer at an altitude of 224 m. One of them was an epigeous gasteromycetous fungus. It was identified as *Podaxis pistillaris* (L : pers.) Fr. It may be mentioned here that *Podaxis* Desv. is a monotypic genus of the family Podaxaceae (Order - Podaxales, Subclass - Gasteromycetes, Class - Basidiomycetes) having a single species *pistillaris* (Bessey, 1950).

Podaxis pistillaris was described first by Linnaeus in 1771 as *Lycoperdon pistillare* L. based on a fungus collected from India. Ten years later Linnaeus (1781) described another fungus as *Lycoperdon carcinomale* L. collected from Cape of Good Hope, South Africa. This fungus is eaten by natives in Africa and they use it to cure cancerous sores (Morse, 1933). As it is used to cure cancer i.e. 'carcinoma', Linnaeus coined the species name for this fungus as *'carinomale'*. However, from a detailed study Morse (1933) concluded that *Lycoperdon pistillare* and *Lycoperdon carcinomale* to be the same species and the correct nomenclature of this fungus is *Podaxis pistillaris* (L. ex Pers.) Fr.

Distribution

This fungus is cosmopolitan in distribution. It has been recorded from all of the five continents - Africa, Asia, Australia, Europe and the Americas though intermittently in somewhat restricted areas in a belt encircling the earth approximately within the fortieth parallels North and South of the Equator. In India it has been found to grow in Andhra Pradesh, Chandigarh, Maharashtra, Orissa, Punjab and Uttar Pradesh (Bilgrami *et al.*, 1991). A survey of literature (Bilgrami *et al.*, 1991; Mukherjee and Juneja, 1975; Sarbhoy *et al.*, 1986; Tandon and Chandra, 1976; Tilak and Rao, 1968) reveals that it was not reported from Rajasthan earlier until this collection from Jaisalmer on 26th September, 1997. So, this report constitutes its first record from Rajasthan.

Ecology

Most of the basidiocarps of *Podaxis pistillaris* collected from Jaisalmer were found to grow on sandy soil as saprobe but some were found associated with roots of *Prosopis juliflora* (Sw.) DC. No such association between *P. pistillaris* and *P. juliflora* has been recorded earlier by any worker. Probably it is mycorrhizal association between *P. pistillaris* and

P. juliflora. In Jaisalmer this fungus grows scattered after rains. Similar observation was made by Smith and Smith (1973) in Southwest desert of USA.

Morphological and anatomical characters of this species based on the collections made from Jaisalmer are given below.

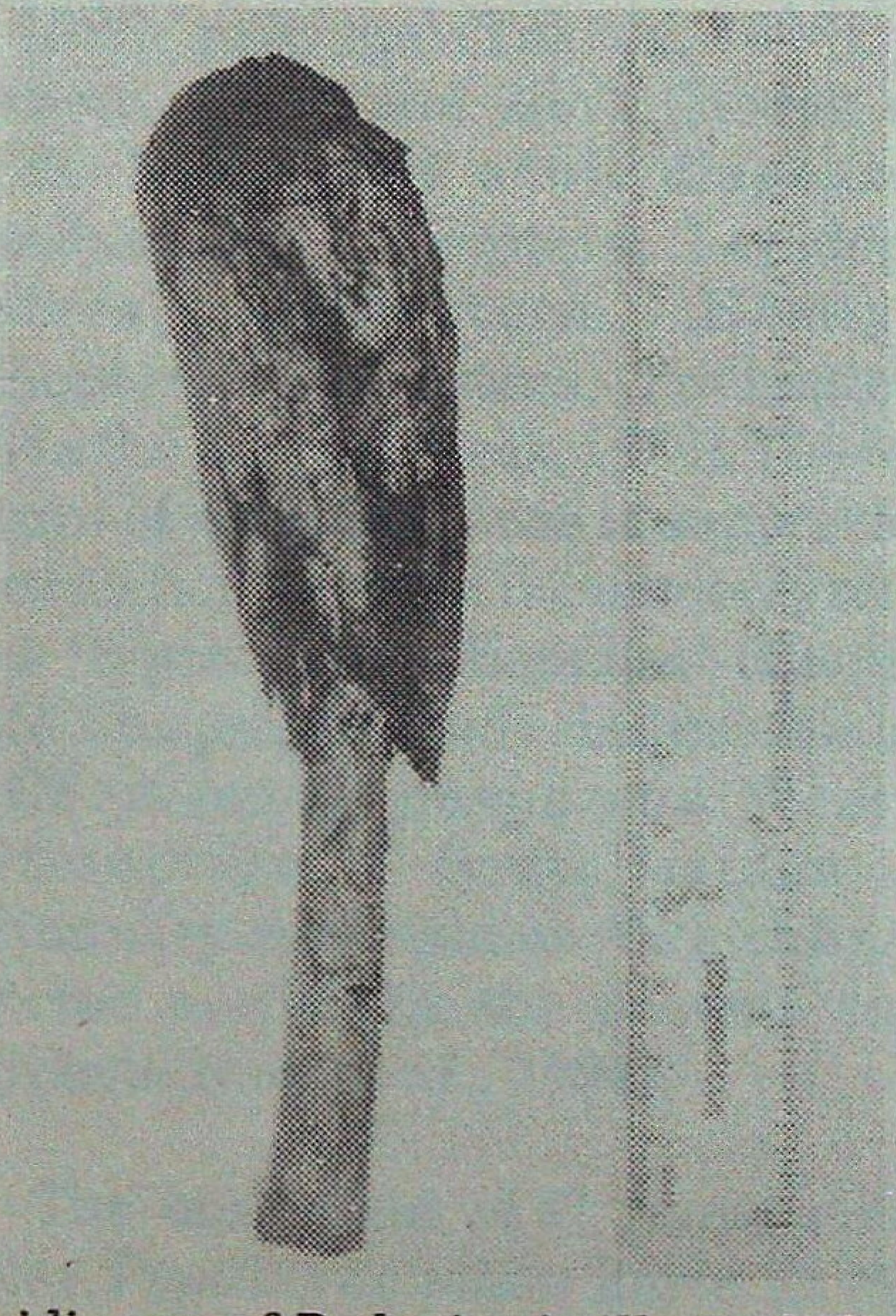
Materials and Methods

For studying microscopic structures of the basidiocarps glebal tissue was teased apart by fine needles, stained with cotton blue and mounted in lactophenol.

Description

Morphology : Basidiocarp (Fig. 1) usually solitary, rarely gregarious, upto 15 cm long, greyish white in colour, consisting of a stipe and a cap. Stipe solid, firm, rigid and woody with a bulbous base, upto 7 cm long and 1.5 cm wide, at first squamulose, becoming smooth or longitudinally striate at maturity. Cap pyreform, ovate to narrowly elliptic, upto 10 cm long and 3.5 cm wide with a leathery peridium enclosing the gleba. Peridium two-layered, outer layer i.e. exoperidium splits into thin scales giving the plant a shaggy appearance. Endoperidium 3-4 mm thick, ochraceous. The stipe extends well up into the gleba and reaches up to the apex and unite there with the peridium. The gleba is developed between the stipe and the peridium which is white in the youngest plants but at maturity become dark brown. The peridium pulls free from the stipe at its lower edge or splits near the latter exposing the powdery gleba.

Fig. 1



Basidiocarp of *Podaxis pistillaris* (L:Pers.) Fr. (x 1/2)

Anatomy : From glebal tissue basidia bearing basidiospores are produced which are interspersed with numerous capillitia. Capillitia originate from the stipe and grow towards the peridium without actually being attached to it. Capillitia olivaceous to reddish brown, sparingly septate, rarely branched, sometimes spirally coiled, 4-20 µm wide. Basidia are produced in cluster on global hyphae. At maturity the basidia and their supporting hyphae are not destroyed. Basidiospores powdery, globose, reddish brown, smooth-walled, wall 2-3 µm thick, two-layered with a germ pore, 10-16 x 9-12 µm.

The voucher specimens have been deposited in the Mycological Herbarium of Burdwan Raj College (BRCMH RG 971, BRCMH RG 972, BRCMH RG 973, and BRCMH RG 974), Burdwan, West Bengal, India.

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(II)

OCCURRENCE OF REPRODUCTIVE DIAPAUSE IN *CHRYSOCORIS PURPUREUS* WESTWOOD (HETEROPTERA : SCUTELLERIDAE)

Diapause or arrested development, is a developmental decision or option in the ontogeny of insects (Denlinger, 1985). Diapause is generally associated with a low rate of metabolism, low susceptibility towards dryness and unfavourable temperature, and resumption of development can only occur after completion of diapause development in a certain period of adverse conditions (Isobe and Goto, 1980).

Diapause occurs at different developmental stages in different insects, such as embryonic (Yamashita and Hasegawa, 1985), larval (Roychoudhury *et al.*, 1985), prepupal (Takeda, 1978), pupal (Hiruma, 1979) and adult (Hodek *et al.*, 1973). Records of adult diapause are abundant for Coleoptera, Lepidoptera, Diptera, Homoptera, Hemiptera, Orthoptera, Neuroptera, Trichoptera as well as the Acarina (Beck, 1980). The central feature of adult diapause is suppression of reproduction, hence, it is commonly referred to as "reproductive diapause" (Denlinger, 1985). The present study clarifies this aspect in *Chrysocoris purpureus* Westwood (Heteroptera : Scutelleridae), the preliminary observations of which has been reported earlier by the present authors (Roychoudhury *et al.*, 1994).

The host plant of *C. purpureus* was Poplar, *Populus deltoides* Bartr. Ex Marsh, transplanted at Silviculture Nursery, TFRI, Jabalpur (M.P.). Observations on the reproductive behaviour of this insect pest were made during the month of May-June, when the prevailing temperature, relative humidity and light : dark cycle were 35-47°C, 20-70% and 14 : 10 respectively. A good number of adult male and female bugs were collected frequently and dissected in insect Ringer's solution to observe the developmental status of male and female reproductive systems during this adverse conditions. Some of the adult bugs were reared on the same host plant inside rearing cages under laboratory conditions. Occurrence of reproductive diapause in this insect was confirmed through field and laboratory observations.

Diapause initiation

With the advent of scorching heat during the month of May, *C. purpureus*, after adult eclosion showed diapausing behaviour, both in male and female. Though the bugs exhibited feeding activity, but no mating and egg laying were observed, both in field and laboratory. Similar situation has been also encountered in bug. *Pyrrhocoris apterus*, where male bugs maintain a high level of feeding and locomotory activity during diapause and a drop in oxygen consumption can be detected only in the female bugs (Slama, 1964 a, b), but the lack of sexual activity in males suggests that it too is in diapause (Zdarek, 1970). The adult males and females were generally found hiding themselves on the ventral side of the leaves. The hiding behaviour ~~of~~ diapausing adults have been also observed in Colorado potato beetle, *Leptinotarsa decemlineata* (Arnoldi, 1976).

The arrested development of reproduction was confirmed through dissection of male and female bugs and subsequent microscopic observations of male and female reproductive organs. The male and female reproductive systems of *C. purpureus* were basically similar to that of *C. stollii* (Roychoudhury *et al.*, 1987; Mukhopadhyay *et al.*, 1988). In diapausing adult males, it was observed that mature sperms were present but the accessory glands were involuted and gland products not yet synthesized. In females, at adult eclosion, the primary oocytes within the germarium of ovary were present, but no vitellogenesis was observed. According to Denlinger (1985), the most conspicuous aspect of adult diapause in females is a halt in the process of oogenesis. Suppression of reproduction as recorded in the present study shows similarity with the observations of earlier workers on some other adult diapausing insects (Slama, 1964 a, b; Arnoldi, 1976).

Diapause termination

With the onset of rain and subsequent lowering of temperature and increase of humidity during the month of June, the adult buts of *C. purpureus* showed gradual diapause termination, both in male and female. Sexual activity resumed and frequent matings observed. One to several males were often observed in close proximity of the females, which resulted in a clumped distribution of males and of the adult population as a whole. Similar behaviour of Heteropteran bugs has been also previously reported (Roychoudhury and Joshi, 1995). According to Nakasuji *et al.* (1965), clumped distribution of males can result from physiological processes related to mating behaviour.

Diapause termination was confirmed through dissection of male and female reproductive organs. In males, accessory glands were convoluted and presence of synthesized gland products were observed. In females, synthesis and uptake of yolk proteins in the pre-vitellogenic oocytes were recorded and in few cases, formation of chorionating and chorionated eggs were observed. These findings clearly indicate the resumption of reproductive growth and are in complete agreement with the observations of Roychoudhury *et al.* (1987) and Mukhopadhyay *et al.* (1988) on normal reproductive development of *C. stollii.*

As a whole, the present study suggests the occurrence of reproductive diapause in adults of *C. purpureus* during the period of high temperature, long photoperiod and less humidity. Diapause in this case may be more correctly called as "summer diapause" in adult insects (Masaki, 1980), which is possibly under the environmental control over the neuroendocrine system (Denlinger, 1985).

Acknowledgements

Authors are thankful to Dr. B.N. Gupta, IFS, the then Director, TFRI, Jabalpur (M.P.) for encouragement and providing research facilities.

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(III)

THE ECONOMICS OF SANDAL-OIL

Introduction

Sandalwood is perhaps the most precious wood in the world today. With its value reportedly around Rs. 17,00,000 to Rs. 20,00,000 per tonne in the international market it is unlikely that any other wood is more prized that Sandalwood. The only other wood that might rival as a close competitor is Agarwood or *Aquilaria agallocha* that is highly sought after by the Arabs. In case of Agarwood only the fungal infected dark-portions are prized for its smell and oil, the rest being as good as fuelwood. However, occurrence of such infected portions are sporadic. In case of Sandalwood, every part of the heartwood yields an essential oil that is now estimated at Rs. 50,000 per kg in the international market.

Who buys and why ? : The bulk of Sandalwood and its oil is used for religious purposes. In India it is used mostly in the South while abroad, the biggest consumers are the Parsis, Muslims and Buddhists who burn Sandal powder as incense. Next comes the perfumery industry. Due to its excellent fixative property, Sandal oil is extensively used in perfumery, toiletries and cosmetics. In India the main consumer is the soap industry while it is the perfumery industries of Europe and the West. Initially, though Sandalwood was prized for its medicinal uses, its use in pharmaceuticals today has declined considerably in face of modern medicines. Today its use in preparation of cures may not exceed 10% of the total production. Among its medicinal uses are its use as astringent, cure for vomitting, gonorrhoea and also as anti-aphrodisiac.

The use of Sandalwood in handicrafts and wood-carving is negligible compared to the above listed uses. Lack of supply of quality wood has greatly affected this traditional industry. In the beginning of this century, Sandalwood was being used for making coffins for the rich in Japan and China, a luxury now no longer affordable for lack of good size logs.

Sandal oil industry : A Brief History

Prior to the Ist World War, the entire Sandalwood was being shipped to Germany for distillation and sale. With the involvement of Germany in Ist World War against England, export of Sandalwood to Germany was stopped and the first Sandalwood distillation factory in India was set up 1916 in Bangalore by Sir Alfred Chattertan, the then Director of Industry and Commerce to Government of Mysore. Presently, Government owned distilleries are running in Kerala, Karnataka, Andhra Pradesh, Maharashtra and Uttar Pradesh. The distilleries in Tamil Nadu were closed down in 1989. Due to the absence of Sandalwood possession rules in Kerala, unlike Karnataka and Tamil Nadu, many Sandal-oil distilleries are flourishing along Kerala and Tamil Nadu border, specially in and around the tri-junction area of the three Southern States. These distilleries today are the main cause of concern for the forest officials who suspect their large-scale abetting and indulgence in Sandalwood smuggling. The Government owned distilleries are presently producing about 150 tonnes of Sandal oil annually. The total domestic production is actually much higher as a considerable amount of clandestinely produced Sandal oil goes unaccounted for.

The Indian Sandalwood oil, known as the East Indian Sandalwood oil in trade parlance, is best in the world in terms of quality and essence. Till the 1980s, India was the leading exporter of Sandal oil, exporting about 100 tonnes annually. But production started falling due to fall in the extraction of Sandalwood and poor outturn of the extracted wood. Decline in the quality of the heartwood and yield per tree is now a major cause of concern. Genetic erosion and absence of commensurate regeneration are the main reasons for the falling standards. Of late, with the advent of the cheaper Indonesian oil and development of several synthetic substitutes, India's monopoly in this trade no longer stands.

Sandal Oil : Its chemical composition and mode of extraction

The main constituent of Sandal oil is 'Santalol' which is basically a sesquiterpene alcohol. It constitutes about 90-94% of the oil; the rest consisting of ingredients like acids, aldehydes, ketones, etc. The colour of Sandal oil varies from pale-yellowish to colourless.

In India, Sandal oil is mostly extracted by the conventional steam-distillation method. Normally distillation is done for 100 to 120 hours per tonne at a pressure of 0.232kg/cm^2. This method though comparatively cheaper, suffers from several drawbacks. Due to the hydrosolubility of some constituents of Sandal oil, certain proportion is left back in the wood. Also, the high steam temperature leads to loss of fragrance.

The improved solvent extraction method followed by vacuum distillation gives 10% more yield. But this method is not followed by most due to the costs involved. Studies have revealed that the optimum size-mixture of Sandalwood powder for distillation is in which 75% of the powder is of 12-36 mesh size and the rest below 12 mesh size.

Oil yield and market price prediction

A knowledge of oil yield and prevailing Sandalwood prices can enable one to easily predict the existing minimum price of Sandal oil in the domestic as well as in the international market.

Yield of Sandal oil depends on which part of the tree the oil is extracted from and on the wood colour. Gas liquid chromatography studies of different parts of Sandalwood has revealed the following yield percentage :

Roots - 7.43%;
Billets - 4.94%;
Chips - 3.1% (Basola bukhini).

It is to be noted that in the roots, the knots called Ainchilta contains the maximum quality of oil. Sapwood does not contain any oil. Inspite of this scientifically established fact, the distilleries in Kerala are claiming to be extracting as much as 8% Sandal oil from sapwood. Surprisingly, their claims are being accepted by the concerned authorities.

The colour of the wood also has an important bearing on the yield of oil. Studies on heartwood colour and oil content derived from 5000 trees have given the following information (Table 1).

Table 1

Heartwood colour	Percentage of oil obtained (Range)
Light brown	2.5 - 6.2
Yellow	2.0 - 3.5
Brown to dark brown about	2.5

So we see that light brown heartwood shall yield more oil than yellow or dark-brown wood. In other words, light brown wood shall fetch the highest price.

Now taking average yield as 5%, the expected minimum prices of Sandal oil in various years can be determined by considering the average price fetched by Sandalwood during the yearly auctions. An additional 20% is being added to cover extraction-cum-minimum profit. (As a case-study Table 2 has been prepared based on Salem Sandalwood prices for last 10 years).

The list in Table 2 gives the minimum expected price only. However considering that Sandalwood is now fetching about Rs. 2000 per kg in the international market, the minimum expected price comes close to a whopping Rs. 50,000 per kg.

Recent market trends

If we note the average prices of Sandalwood fetched in 1994 and 1996, we notice that in 1996 there is a 100% increase in the price of Sandalwood. So, while it look 6 years for the price to double from 1988 to 1994, it doubled in just 2 years by 1996. In fact, it is worth mentioning that one lot of Jajpokal (special) category in Tirupattur had fetched an unprecedented Rs. 9,00,000 per tonne during auction in July 1996. But why this sudden jump in Sandalwood prices? Is it that demand of Sandal Oil has suddenly risen? While in the domestic market it is most unlikely in case of the international market, demand fluctuations cannot be predicted with certainty. One reason however can be attributed to the Export-Import (EXIM) policy. Under the present EXIM policy that expires on 31.3.97, there is a blanket ban on export of wood or timber in any form other than as finished products like handicrafts. (Vide chapter XVI, negative list of exports part-I, Sl.158 prohibited items). But there is a provision in part I, Section 162, Sl. No. 21, where Sandalwood items in form of handicrafts or machine-finished items can be exported without license. There is a rising expectation among the Sandalwood merchants that the ban on export of Sandalwood may be lifted in the next EXIM policy. With the reported price of Sandalwood in international market around Rs. 18,00,000 - 20,00,000 per tonne, the

Table 2

Year	Average price per kg of Sandalwood (Rs.)	Minimum expected price of Sandal oil per kg (Rs.)
1986	91.47	2195
1987	123.90	2973
1988	130.00	3120
1989	143.90	3454
1990	207.40	4978
1991	260.85	6260
1992	263.30	6319
1993	258.70	6209
1994	260.00	6240
1995	No sale	-
1996	527.00	12648

Source : Salem Sandalwood Sale Depot.

N.B.: Average price is calculated by considering value of Sandalwood upto Jajpokal Ist class i.e., Xth category.

merchants are willing to pick up at double the price with the hope of making a neat 200% profit once the ban is lifted.

In India the main market of Sandal oil is Kannuaj in Uttar Pradesh followed by Delhi, Calcutta and Mumbai. Kannauj accounts for nearly 60% of the total Sandalwood oil sold in the country. Kerala is most likely the leading producer of the oil, the bulk of which is produced and subsequently sold illicitly.

Synthetic substitutes and Adulterants

With the sharp increase in the price of Sandal oil, and also due to the uncertainty of availability of the product, perfumeries are gradually switching over to its cheaper substitutes. Among the synthetic substitutes, the most successfully marketed substitute is 'Sandela' that costs 1/3rd of the natural oil. Other substitutes includes santalydol, hydrogeneted catechol etc. But none of these substitutes can compare with the natural oil in quality and aroma.

Considering that the international price of Sandal oil is around Rs. 50,000 per kg, adulteration can lead to substantial profiteering. Among the possible adulterants are the high boiling esters like di-ethyl phthalate, glyceryl triacetate, isopropyl myristate, etc. Alcohols like terpeneol, geraneol, etc., are also being used as adulterants.

Conclusions

Most of Sandal bearing tracts in Tamil Nadu are being subjected to systematic vandalisation by the smugglers and unscientific extraction by the Department. The average yield of heartwood has come down to the abysmal figure of 3.6 kg per tree (Salem Depot, 1995-96 figure). Without commensurate regeneration, the future of the Sandal tree is very threatened. If the present rate of illicit extraction is not effectively checked, Sandal tree may face the prospect of extinction by the turn of the century.

Sandalwood products can be afforded only by the rich and the affluent and serve no purpose to the people in general. It is equally disturbing to note that the entire exercise of Sandalwood extraction, presently one of the prime activities of the Tamil Nadu Forest Department, is bringing in very little tangible benefits to the forest and the tribal people living in and around the forest belt. No effort has been taken to wean away the local tribals from indulging in illicit felling of the Sandal trees. Politicisation of occasional sincere efforts have sometimes boomeranged against the forest officials. The Department is presently fighting a losing battle against the better equipped smugglers. All the 'hulla-balloo' at the top on Sandalwood protection is yet to crystallize into concrete support to the ground level officials. Very little of the money raised by Sandalwood auction has been invested for Sandalwood protection. Lack of vehicles, adequate fuel-ceiling and infrastructural facilities have seriously hampered the protection efforts. It is time that we looked beyond the narrow confines of revenue generation and proud claims of Sandalwood seizures and consider the larger perspectives of tribal socio-economic scenario and holistic forest-management.

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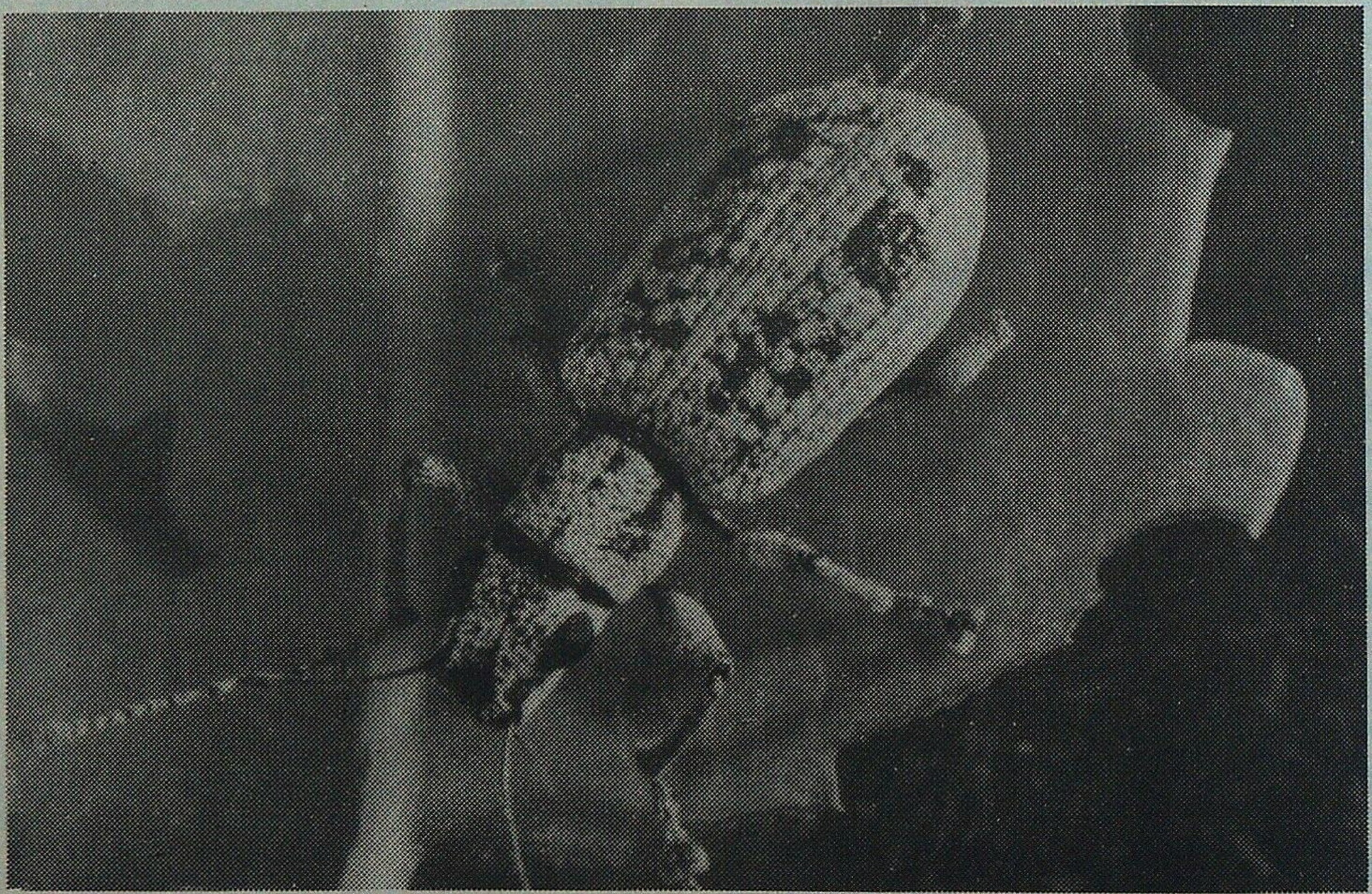
(IV)

MYLLOCERUS TENUICORNIS FAUST (COLEOPTERA : CURCULIONIDAE), A NEW PEST RECORD ON NEEM *(AZADIRACHTA INDICA* A. JUSS) FROM INDIA

Myllocerus tenuicornis Faust, a polyphagous and the primary pest of Plums and *Acalypha* spp, has now been reported to feed on Neem tree in arid and semi-arid areas. Adults of this golden weevil are observed infesting leaves of Neem in plantations grown under Neem provenances trials at Jodhpur District, Rajasthan. A moderate attack of *M. tenuicornis* starts from the months of June and continues till December. So far, two species of *Myllocerus* viz., *M. dorsatus* Fabr., and *M. laetivirens* Marshal have been reported to cause damage to Neem (Tewari, 1990; Kumar *et al.*, 1997; Kumar and Ahmed, 1977). The adults of these two species have been reported to feed on Neem leaves.

Adults are found voraciously feeding on tender leaves in comparison to that of older leaves. Sometimes two or three weevils are found congregating on ventral surface of leaves, nibbling irregular holes and gradually eating away the entire leaf laminae, leaving only the midribs intact. The tender leaves are eaten first and then the older leaves are also skeletonized. The

Fig. 1



Adult Weevil of *Myllocerus tenuicornis* Faust, feeding on Neem foliage

pest causes the maximum damage to foliage during the rainy season and the attack by this species continues till the end of December. Copulation behaviour was noticed from June to October and the mating period ranged from 10-15 min., with an average of 12.80 ± 0.137 min. and then both the individuals move to opposite directions. Eggs are laid after 24-36 hours of mating on the young leaves and branches. The eggs are broadly oval in shape, creamy-yellow, smooth, transparent, shiny and measure 0.15 ± 0.001 mm in length and 0.04 ± 0.001 mm in width. The eggs are either laid in the form of ootheca or in cluster which are clumped together with gelatinous material. The hatching (incubation) period requires 5-6 days. Extreme apodous or eruciform larva hatches out of the egg. The soft bodied apodous larvae have reduced mouth parts and they feed on tender leaves and decaying matter of the forest floor and ultimately undergoes pupation. Pupal period lasts 6-7 days. *M. tenuicornis* undergoes hibernation in pupal form in the month of December. Almost immediately after emergence, the adults disperse and start feeding on the leaves of the Neem plants. Severe feeding results in partial defoliation in tender foliage of young seedlings. Appearance of adult weevils starts by the beginning of mid-June and further population starts building up in the middle of July and reaches its peak by the end of August-September and again starts declining by October. Maximum defoliating activity of this pest was observed during the last week of August.

Defence

Adults of *M. tenuicornis* exhibit death feigning or death behaviour, against foreign stimuli and this characteristic is believed to reduce the chance that a weevil will be detected by its predators. When touched the weevils remain motionless for about a minute and then crawl away. This is evidently a self-protection device.

Systematic Account

Class - Insecta
Order - Coleoptera
Family - Curculionidae
Sub-family - Otiorrhynchinae
Genus - *Myllocerus*
Species - *tenuicornis*

Myllocerus tenuicornis Faust, 1891. Stett, Ent. Zeit, 52:267; Marshal, 1916:321 (SMTD).

Diagnostic features

Colour pieceous, metallic green or golden green or golden yellow scaling, and brown or blackish markings or ridges, head with dark patch on vertex, scales on the intervals of two types, 3-4 ridges, wavy apex, 8-10 grooves, golden yellow colour with metallic green patches, setae on the strial margins very long, elongate, hair like erect, golden yellow with brown coloured inner core. Males have pointed abdominal end whereas females have rounded end (Ramamurthy and Ghai, 1998; Marshal, 1916).

Distribution

India - Bihar : Pusa, Ranchi, Saren; Karnataka : Bhadravati, Shimoga; Kerala : Trichur; Maharashtra: Nagpur; Tamil Nadu : Coimbatore, Madurai, Nilgiri, Thanjavur; (Marshal, 1916), Rajasthan : Jodhpur, Bilara, Osian.

Host range

Plums, *Acalypha* spp. (Ramamurthy and Ghai, 1988; Marshal 1916).

Integrated Pest Management

In case of severe infestation in nursery stage spraying of monocrotophos (0.02%) is highly effective in controlling the pest population. Five species of spiders viz., *Calipitrimerus azadirachtae, Eutetranychus maximae, E. orietalis, E. phaseoli, E. bilobatus* exert a potential control by feeding of the egg of *M. tenuicornis*. Entomopathogenic fungus, *Beauveria bassiana* (Balsamo) Vuill. is recorded infecting adult weevils in the field conditions. An unidentified hymenopterus pupal parasite has also seen emerging from the pupae of *M. tenuicornis*.

Acknowledgements

Authors are thankful to the Director AFRI, Jodhpur for providing necessary facilities. The authors are also thankful to Dr. V.V. Ramamurthy, Principal Scientist, Division of Entomology, IARI, New Delhi, for taxonomic confirmation of the species.

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Goldy Mathur

LETTER TO THE EDITOR

To
The Hony. Editor,
Indian Forester,
P.O. New Forest,
Dehra Dun (U.P.)

Sub : Assessment of Value Additions in Afforestation Works

Dear Sir,

I have gone through the above captioned article by Shri S. Paul Raj, published in your esteemed journal in the September, 1998 issue.

In the introduction, the author states that "the objectives of afforestation works in a wildlife sanctuary would be different from that of a watershed". He should have gone further to include open forest, scrub, non forest (which abound in Tamil Nadu as per *State of Forest Report, 1997*) in his study of afforestation works. The author should have thrown some light in this direction analysing the methods and processes in afforesting such areas.

Secondly, under item 5, Rural Employment under material values of afforestation works, the author states that 70 to 80% of total expenditure on afforestation works goes for payment of wages, leaving only 20 to 30% for actual afforestation works. This appears to be somewhat unusual and unsound a policy. The author states "the rural employment value may be assessed based on the percentage of money spent on employment generation out of the total amount sanctioned for afforestation". Admitting that employment generation is one of the main objectives in afforestation programmes (as stated by the author), yet it would have been wise and justifiable if the expenditure ratio between employment generation and actual afforestation works be 50:50. To be precise, at present out of one lakh rupees sanctioned for afforestation, only 20-30,000 goes for actual works and the bulk amount of 70-80,000 go for wages of labourers.

Under Environment Value (Item 7 of material values), it has been stated that "the quantification of the socio-economic value may be determined by the number of families benefitted and the number of families lifted above poverty line as a result of afforestation activities". But what is the yardstick used for measuring these two rather abstract benefits? There is nothing in the article to come to a definite conclusion. These values are difficult to be quantified and so also the "Aesthetic and Scientific Values".

As this is the first attempt to evaluate the afforestation works by identifying all the values detailed, the results achieved as shown in Table 1 and 2 of the article may not be considered as final. The author frankly admits that "it (giving score for each value) is not based on any scientific studies". Anything not based on scientific studies cannot be taken as authentic and unquestionable.

Study Area : The study areas include representation of protected areas (Sanctuary/National Park), major watershed, degraded forest and community land in Tamil Nadu. To include Sanctuary/National Park in afforestation works is rather unscientific, as afforestation works disturb the ecosystem of the protected areas and thereby affect the very purpose for which Sanctuaries and National Parks are maintained, retaining the original habitats of the forest areas. Instead, open forest, scrub and non-forest areas abounding in Tamil Nadu should have been taken up for afforestation works.

My Suggestions :

1. Tamil Nadu having only 13.1% forest areas of its total geographical area ranks 19th in the country so far as percentage of forest cover over geographical area is concerned. Hence, it is suggested that afforestation works be taken up vigorously to achieve the accepted 33% forest area over geographic area.

2. For such scientific studies, different areas representing different types of soil, vegetation and climate should have been taken up. But this does not appear to have been done as apparent from the two tables incorporated in the body of the article and also from the article itself.

3. Each locality will give different results and only averages of these results need to be published in order to be convincing.

4. I hope the author with the co-operation of his course Director and his course colleagues will pursue the research covering different forest types, soil and climate of Tamil Nadu.

Yours faithfully,

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From the Indian Forester - One Hundred Years Ago

THE
INDIAN FORESTER

June 1899 (pp. 229-230)

THE LARGE ELM OF KULU

In October 1876 the large Elm with drooping branches, which in Kulu is known under the name of Marn, attracted my attention. At that time I only found leaves, but a few years afterwards one of my friends sent me specimens in flower and young fruit. In May 1881 I found the same tree in the Pabar valley at an elevation of 4,000 ft., and on the ticket written by me at the time, the vernacular name is stated as Marn. At the Herbarium here there are, besides the specimens collected by myself and by my friend, leaves and a piece of the bark gathered by the late Dr. Aitchison on the Jhelum river between 5,000 and 7,000 ft. The ticket says, "A good sized tree, bark used as rope". There is also a specimen in leaf collected by Dr. Henderson on the Yarkand expedition in 1870, and there are specimens (leaves and young fruit) collected by Dr. T. Thomson in Kashmir in 1848, at 5,000 and 5,500 ft., marked "large tree".

In his "Flora of British India", Vol. V. p. 480, Sir Joseph Hooker has united this tree with the Himalayan Elm, *Ulmus Wallichiana*. This species, however, I knew well in 1876, and had no doubt in my mind that the Marn of Kulu was different. My ticket on specimens of *Ulmus Wallichiana* gathered in Kulu in October 1876 says, "Imbri Maral, a large tree, lopped every other year". On a specimen collected by me in May 1863 in the Amlawa valley of Jaunsar, the vernacular name is given as "Narag". I also gathered it in Bussahir at 6,500 ft. in May 1881, under the name "Imbri", and in Kunawar near Tranda at 7,000 ft. under the name "Maldang".

Ulmus Wallichiana has the young shoots and leaves always pubescent, while those of Marn are perfectly glabous. In *Ulmus Wallichiana* the venation between the numerous parallel secondary veins is very minute, very regular and prominent on the underside, unless obscured by the pubescence. In Marn the secondary veins are also parallel and numerous (15-18 pairs), the tertiary veins are prominent, particularly on the underside, and their branches form an entirely different venation with much larger meshes, than is the case in *Ulmus Wallichiana*. The chief difference, however, consists in the fruit, which in *Ulmus Wallichiana* is glabous, or only slightly pubescent and conspicuously reticulated, while Marn has a villous or silky fruit, with a dense fringe of long white hair on the sharp edges.

It will be a matter of considerable interest to study the Elms of the North-West Himalaya, and to ascertain, whether the "Marn" of Kulu must be regarded as a distinct species. Bark, timber, mode of growth, time of flowering, the appearance of seedlings and other characters should be studied. Both species are in flower early in the season, before the leaves appear, and in both the indehiscent flat fruit is on a long slender peduncle which is articulate near the base.

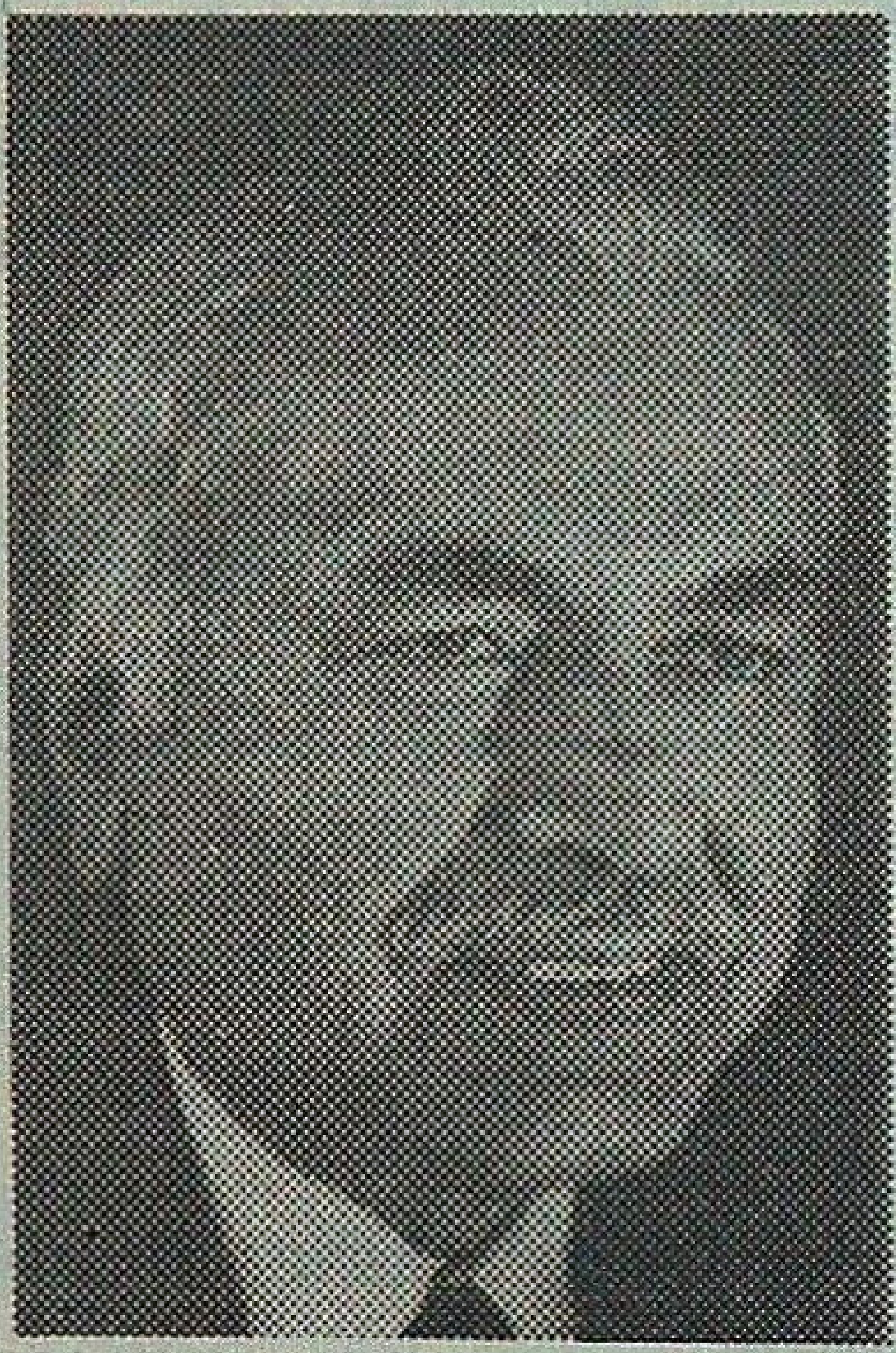
Should the Marn prove to be a distinct species in the judgment of those Foresters who have the good fortune to be working in the North-Western Himalayas, I am disposed to call it *Ulmus villosa*.

- D. Brandis

OBITUARY

K.K. Sharma

(15-02-1931 - 21-03-1999)



Shri K.K. Sharma, 'Chotu' to his friends and colleagues and 'Kaykay' as he loved to call himself, passed away on the morning of 21st March, 1999 after a prolonged illness. He was 68.

Shri Sharma obtained his Masters Degree in Botany from Nagpur University. He was selected for S.F.S. Course in 1954 and then the Indian Forest College, Dehra Dun from ex-C.P. and Berer State. During the course of his career, he served with distinction in various capacities in the State. He was on deputation to Government of India and served as Lecturer both in the Indian Forest College and the Forest Rangers College, Dehra Dun. He went on to work as Conservator of Forests, Working Plan Circle and thereafter as Chief Conservator of Forests, Social Forestry. He retired as Chief Forest Officer, Nepa Mills. His contribution as Chief Conservator of Forests, Social Forestry was particularly noteworthy as he motivated and guided plantations in Private fields and Community lands.

He will be best remembered as on of the finest photographers in the Forest Department. His portraits of a hill woman, a child and the coniferous forests with sheep grazing in the foreground are master pieces of photographic art.

He was very popular with all Forest Officers and Staff. May God grant eternal peace to the departed soul and give strength enough to all those whom he left behind to bear the loss.

-R.K.D.

GAZETTE NOTIFICATIONS

HIMACHAL PRADESH GAZETTE

The Governor, Himachal Pradesh, is pleased to order the equation of the post of Managing Director, H.P. State Forest Corporation Ltd., to that of Addl. Prl. Chief Conservator of Forests in the pay scale of Rs. 22,400-525-24,500 and to promote Shri Gurmeet Singh, IFS (1970) Managing Director, H.P. State Forest Corporation against the equated post of Addl. Prl. Chief Conservator of Forests on regular basis with immediate effect.

On the recommendations of the Screening Committee, the Governor, Himachal Pradesh, is pleased to order the promotion of Shri Pankaj Khullar, IFS (1971) to the newly created post of Addl. Prl. Chief Conservator of Forest in the pay scale of Rs. 22,400-525-24,500 on regular basis with immediate effect.

The Governor, Himachal Pradesh is pleased to order the transfers and postings of the following IFS officers in public interest with immediate effect :-

Sr.No.	Name of Officer	From	To
1.	ShriJoginder Singh	C.C.F. (WP&S) Mandi.	C.C.F. (Wild Life) Shimla.
2.	Shri A.L. Sharma	C.C.F. (Projects) Shimla	C.C.F. (W.P. & Settlement) Mandi.
3.	Shri O.P. Sharma (On Promotion)	C.F. Dharmshala	Executive Director H.P. State Forest Corporation, Shimla
4.	Shri Vinay Tandon (On Promotion)	C.F. (Wild Life) Shimla	C.C.F. (Project) Shimla
5.	Shri R.K. Gupta	Project Director IGCP, Palampur.	C.F. Dharamshala (To hold the charge of Director, IGCP till Shri T.D. Sharma joins)
6.	Shri T.D. Sharma	On training	Project Director IGCP, Dharamshala
7.	Shri Sham Lal	C.F. Rampur	Director, SLUB.
8.	Shri Sushil Srivastava	Director, SLUB	C.F. (R & D)
9.	Shri Sanjeeva Pande (On Promotion)	Director,GHNP, Shamshi	Director, GHNP, Shamshi in the rank of C.F.
10.	Shri Harsh Mitter (On Promotion)	G.M. R&T Factory Bilaspur	Director Marketing H.P.S.F.C.
11.	Shri M.P. Singh (On Promotion)	D.F.O. Karsog	C.F. Rampur

On the recommendations of the Screening Committee, the Governor, Himachal Pradesh, is pleased to order the promotion of the following IFS officers to the post of Chief Conservator of Forests in the pay scale of Rs. 18,400-500-22,400 on regular basis with immediate effect :-

1. Shri O.P. Sharma (1971)
2. Shri Vinay Tandon (1975)

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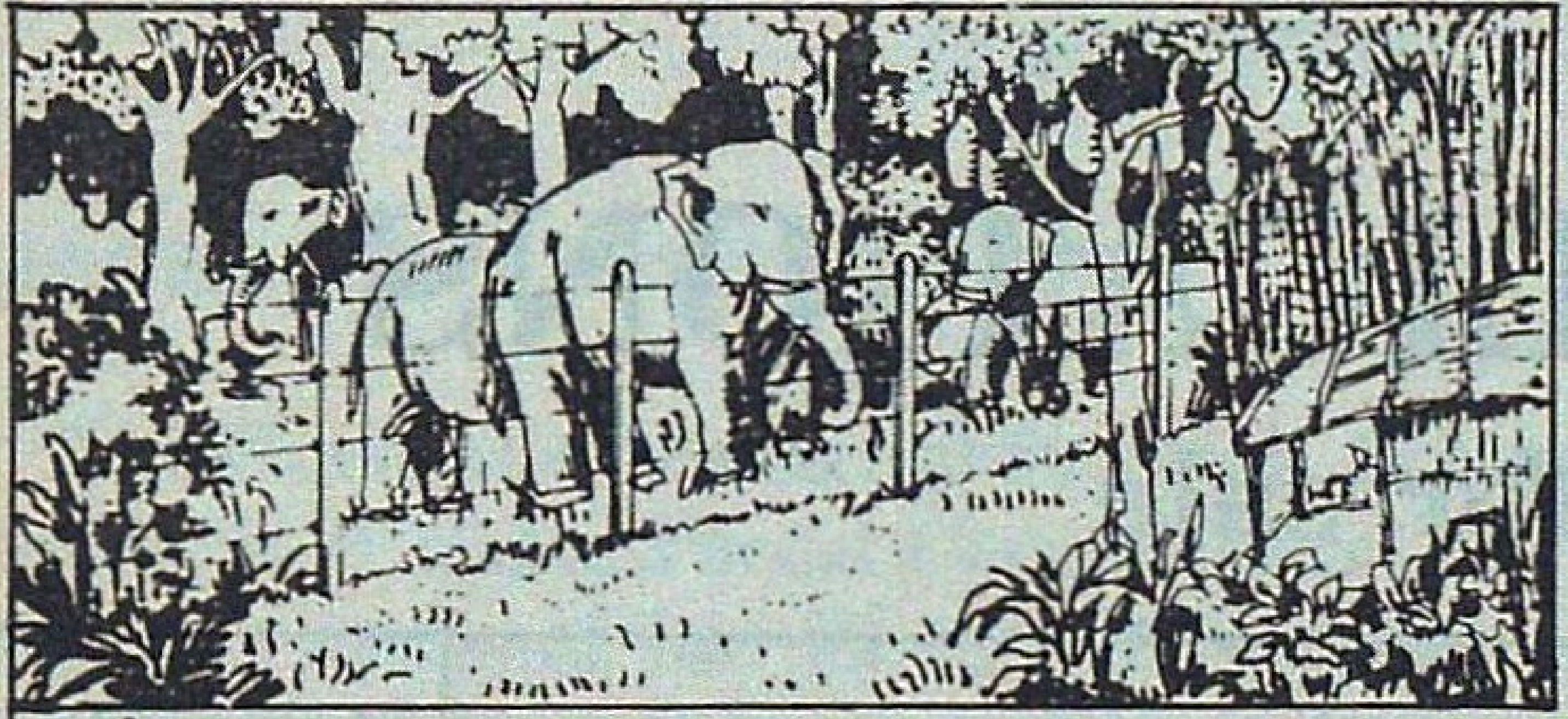

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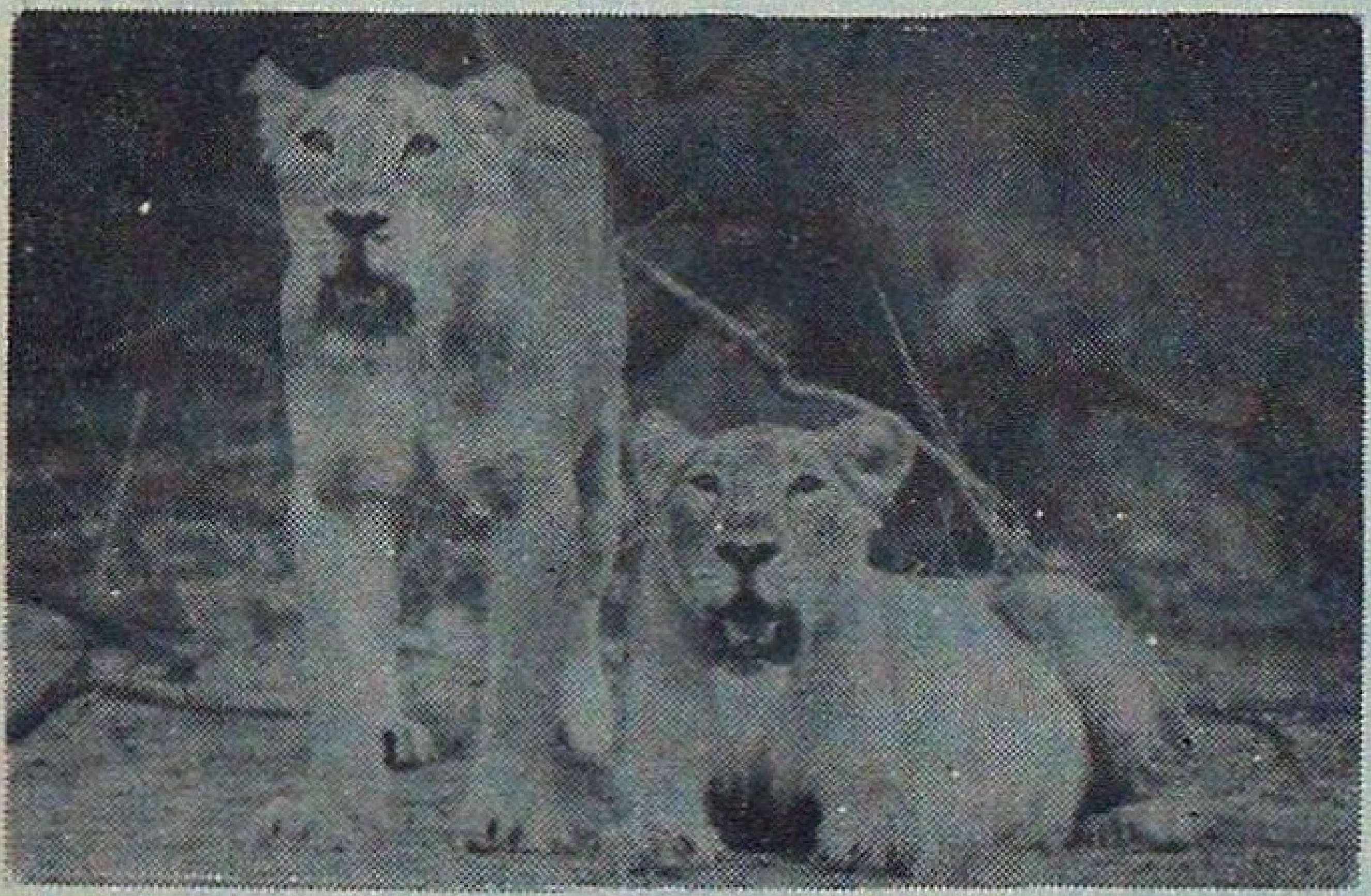

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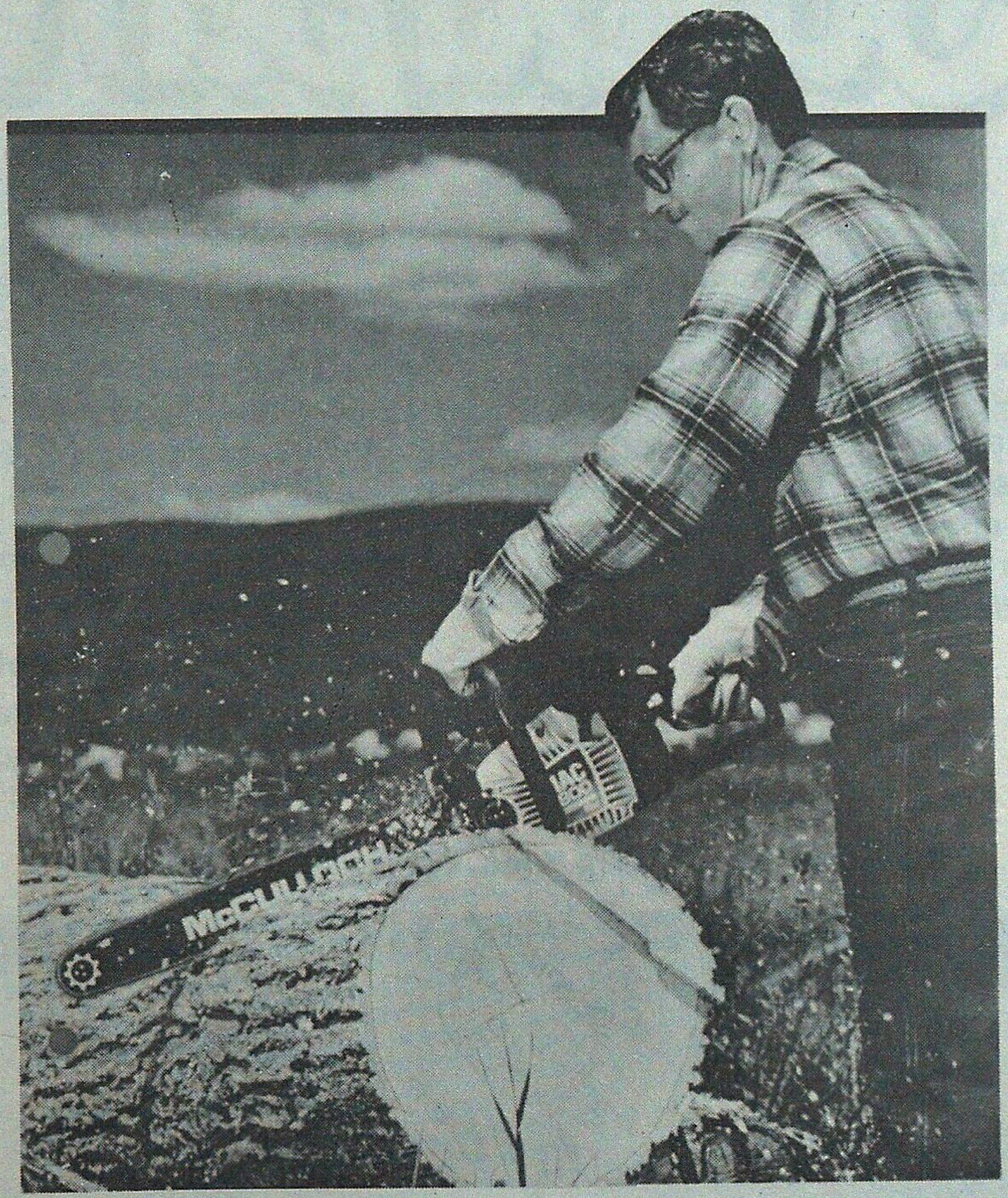

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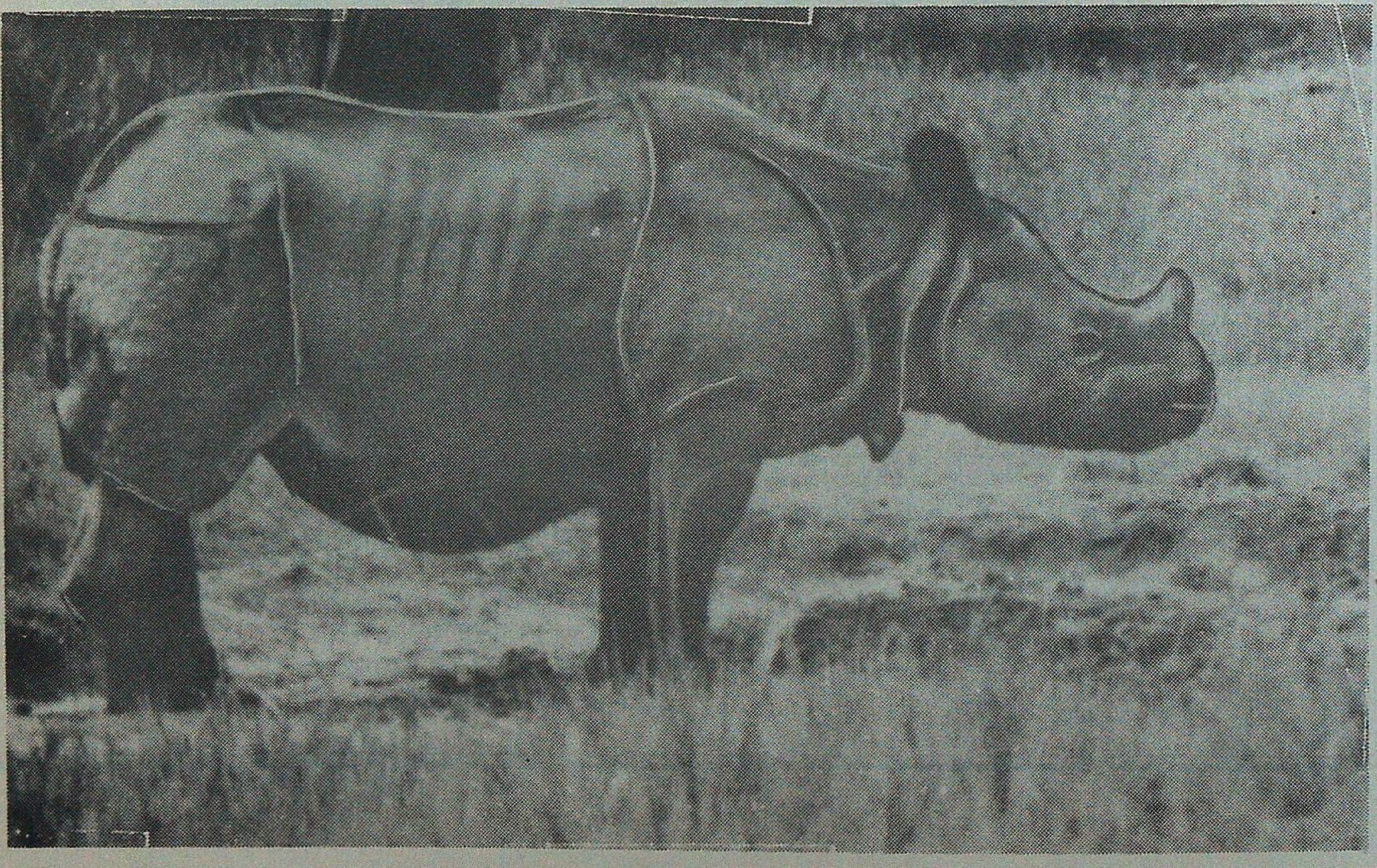

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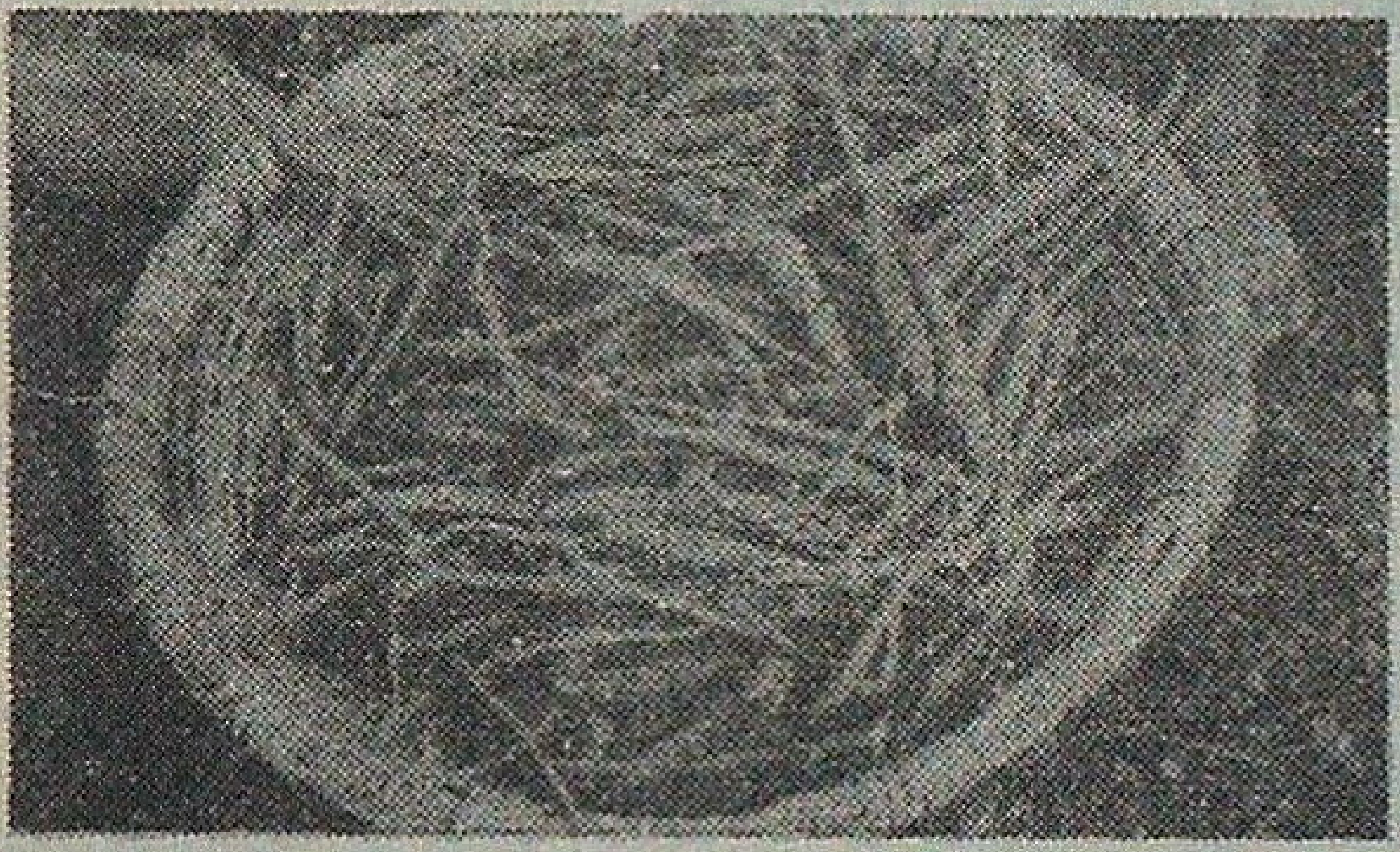

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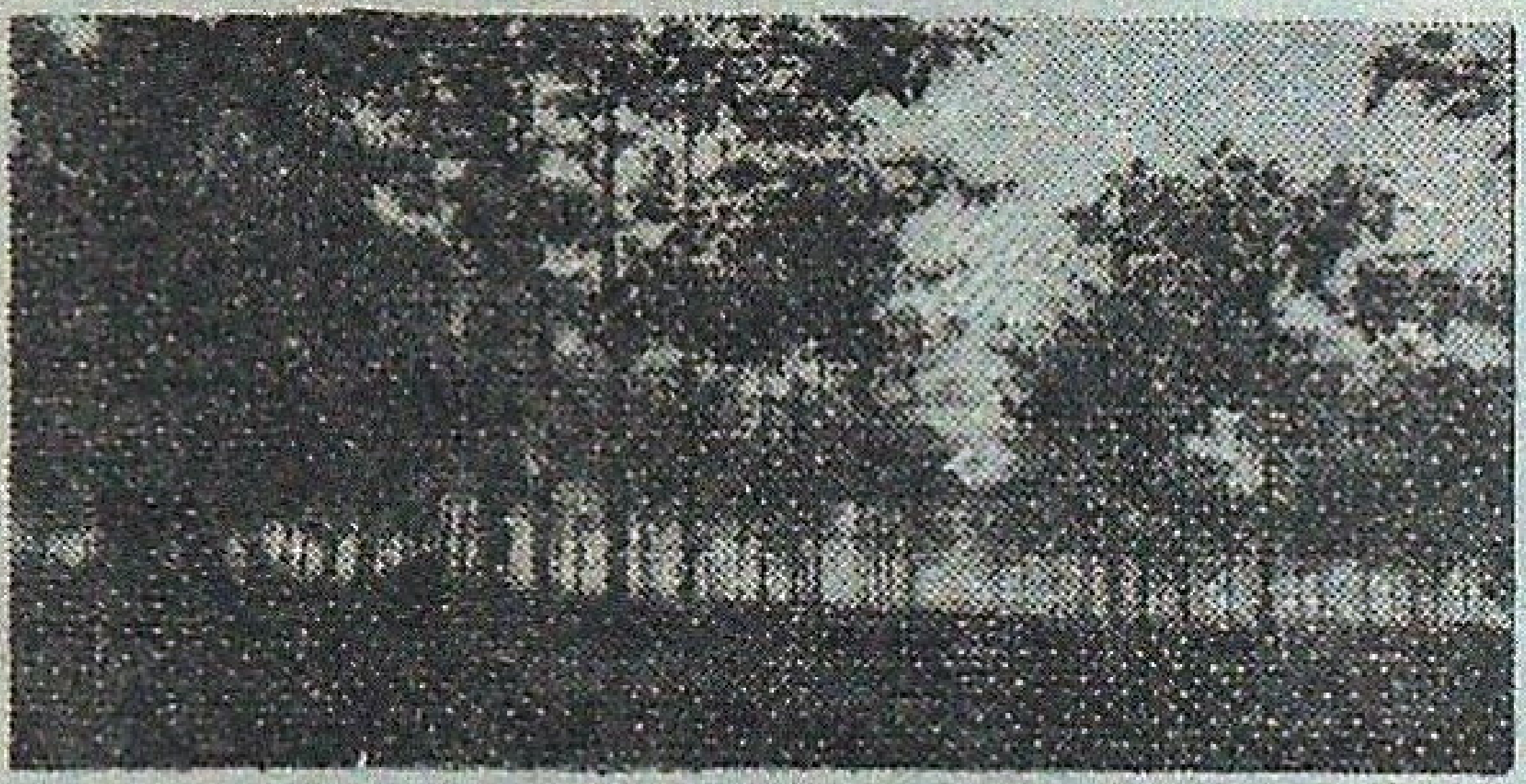

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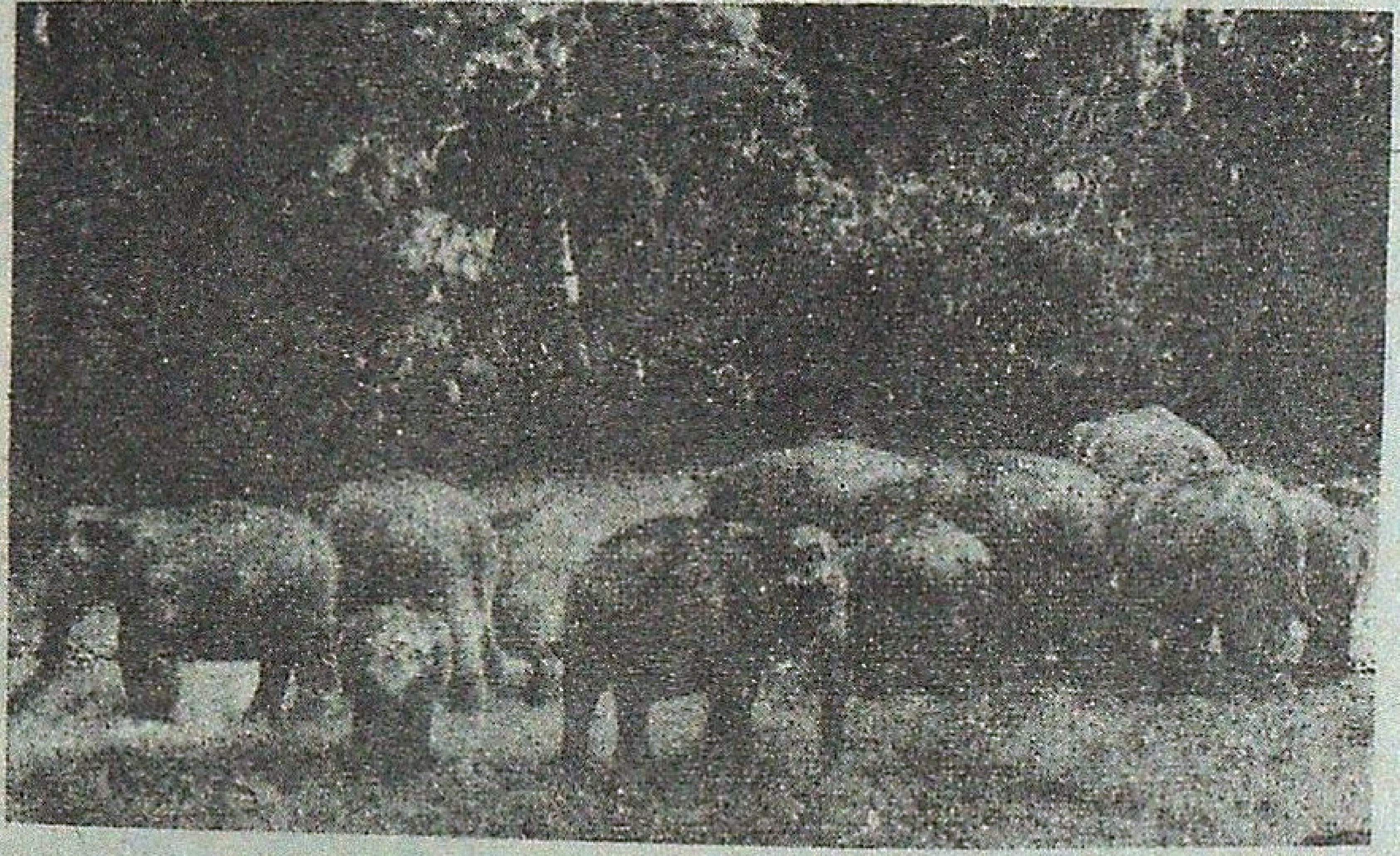

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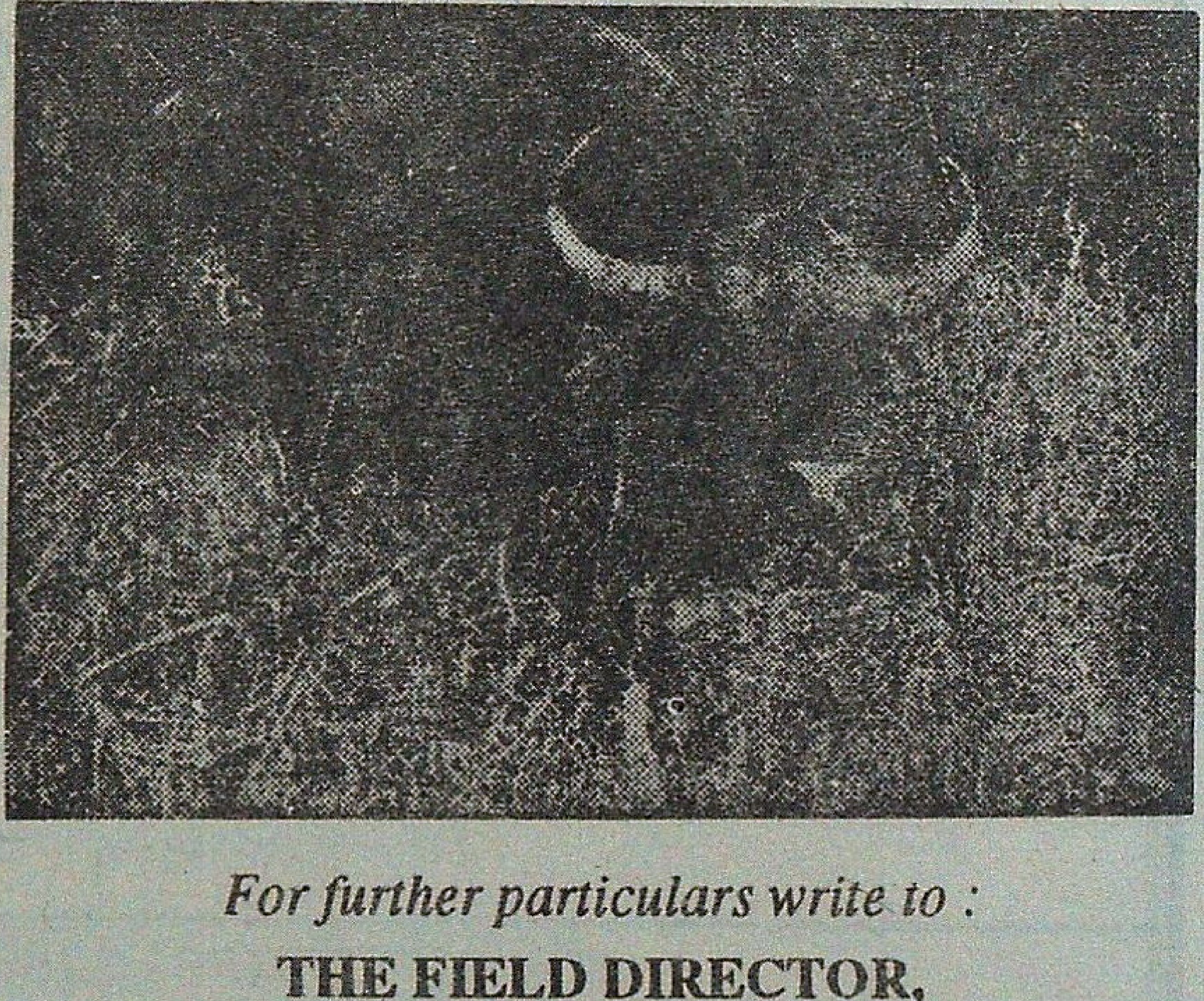

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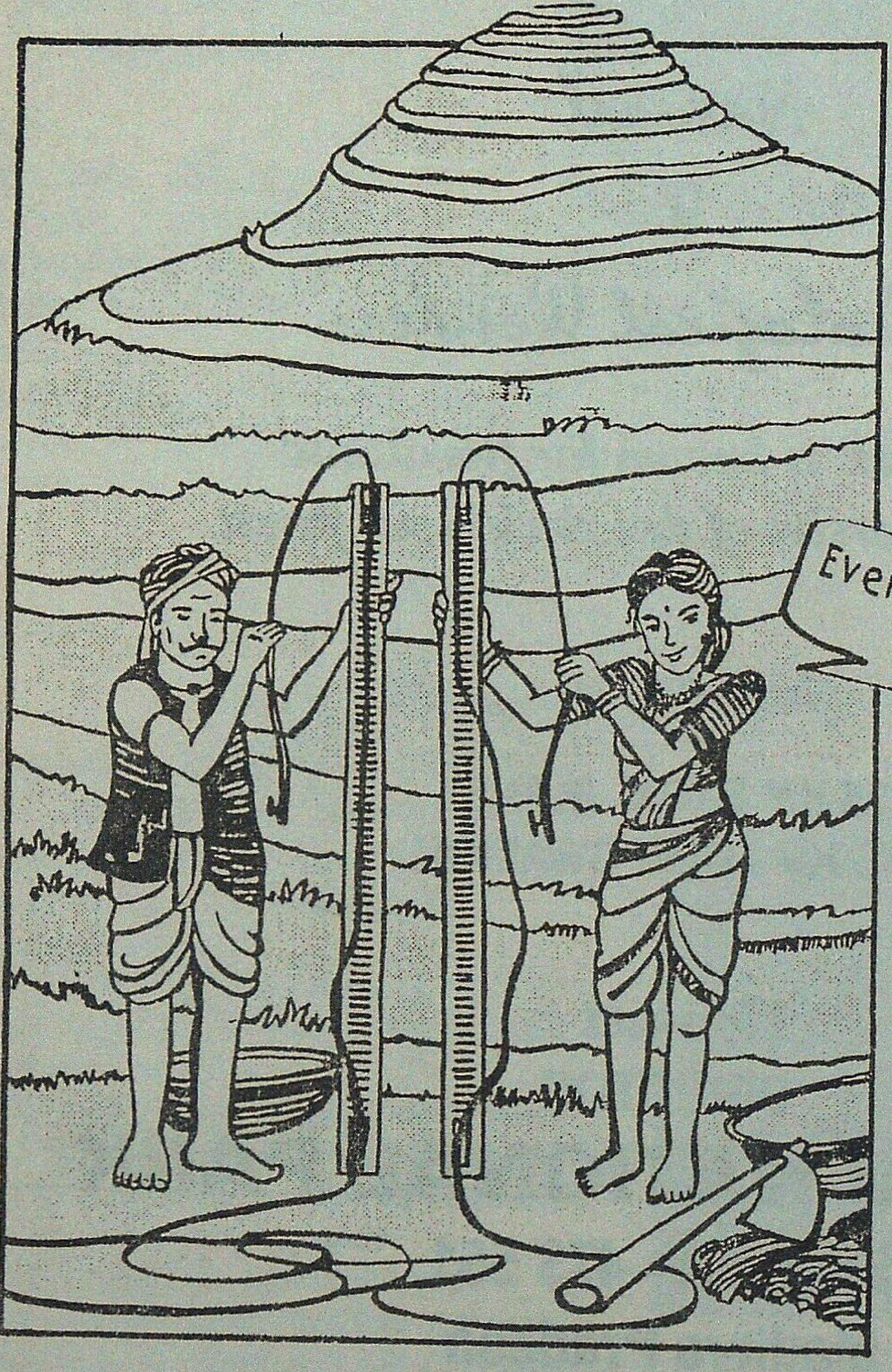
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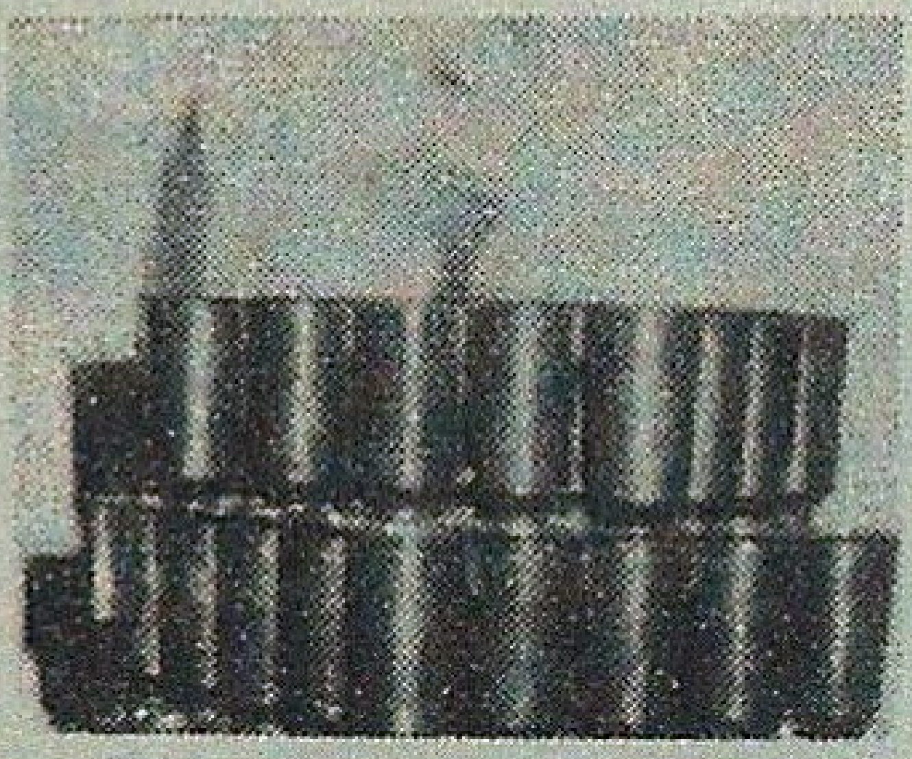

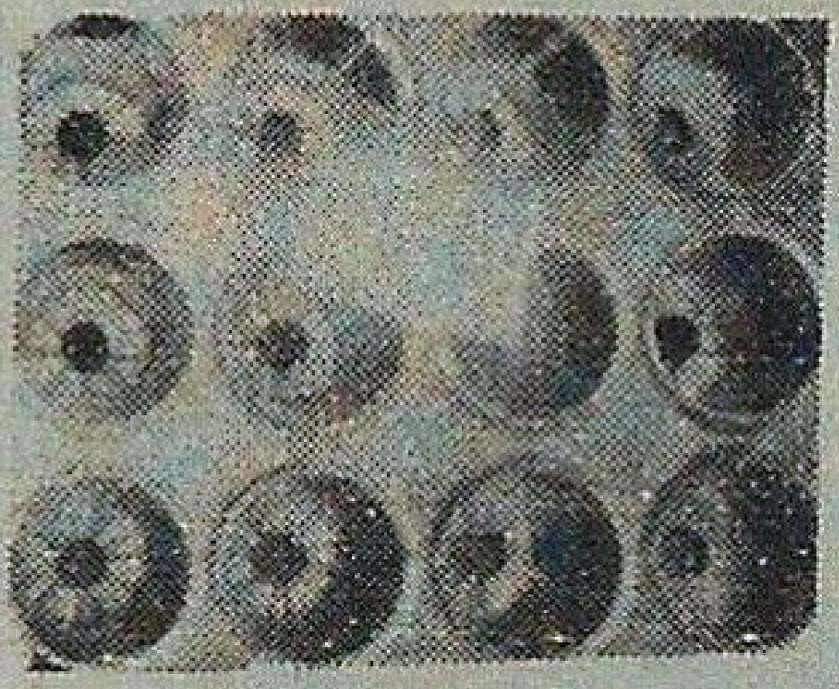

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250 C.C
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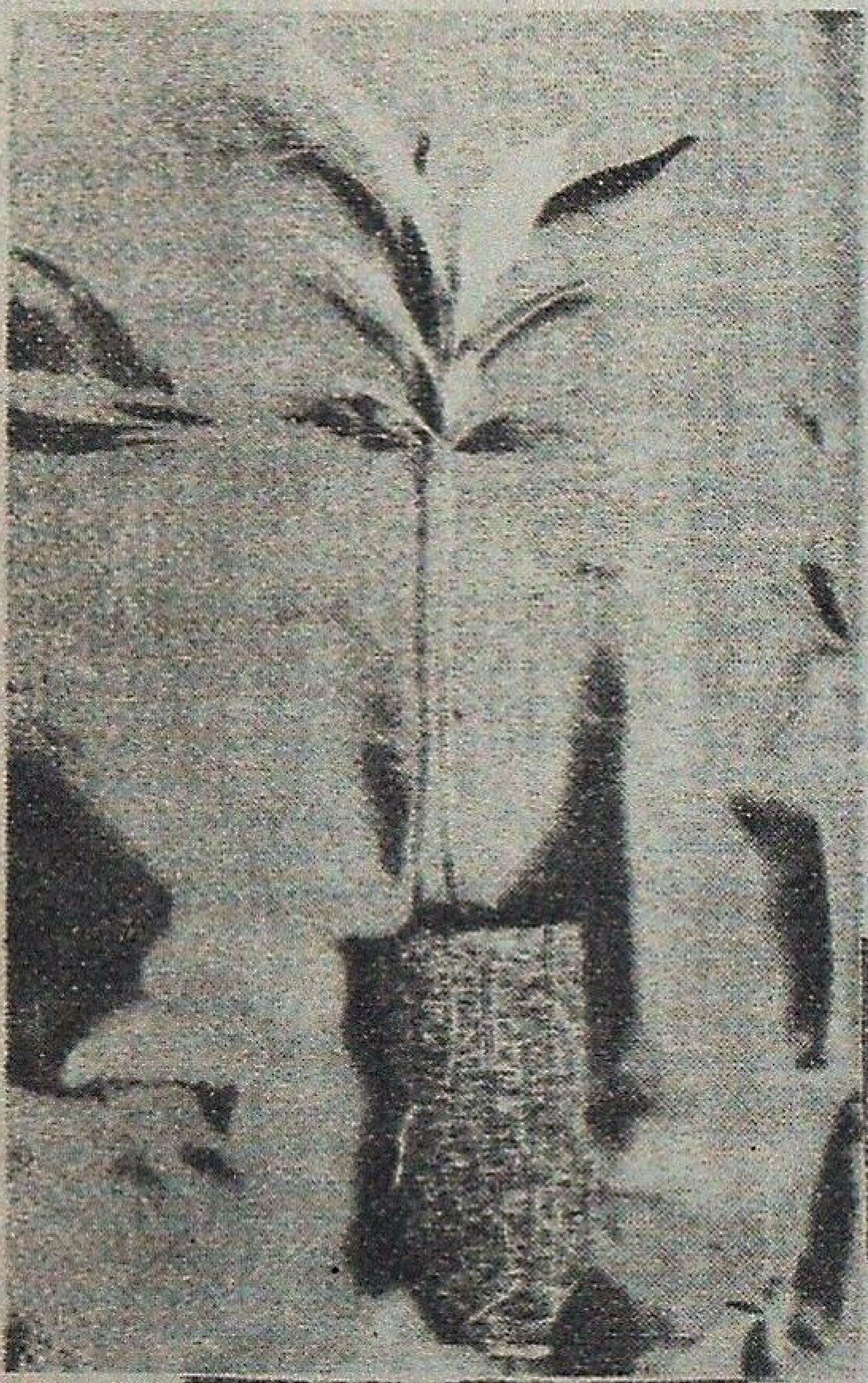
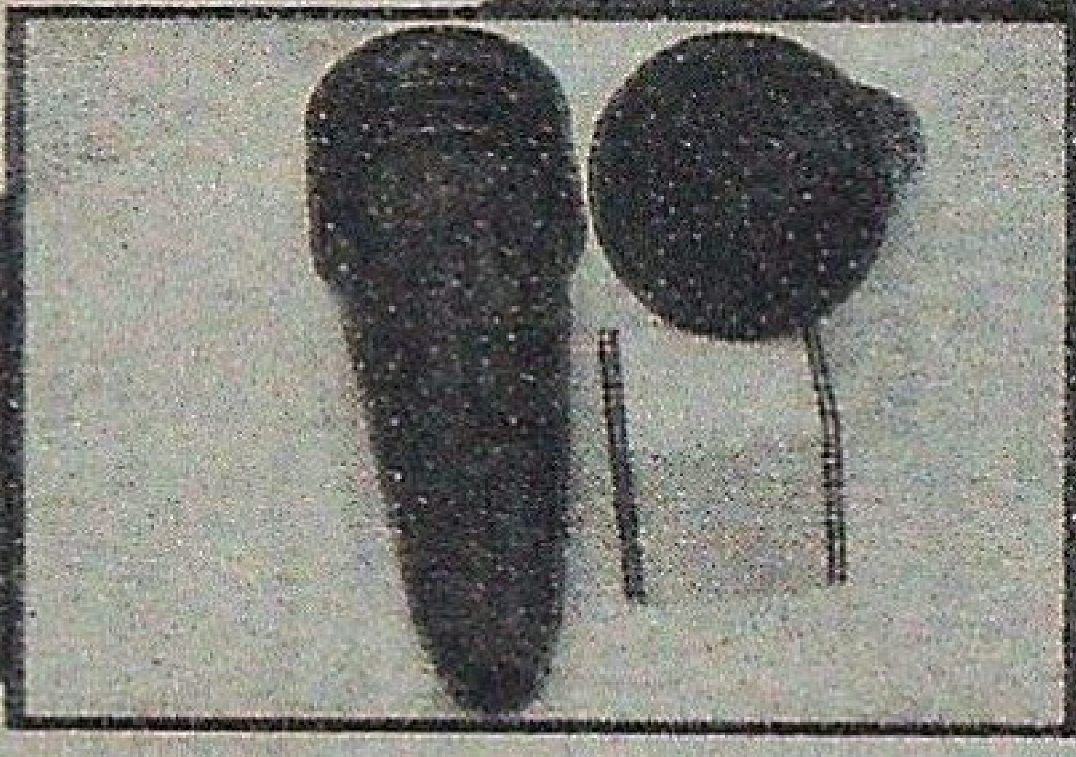
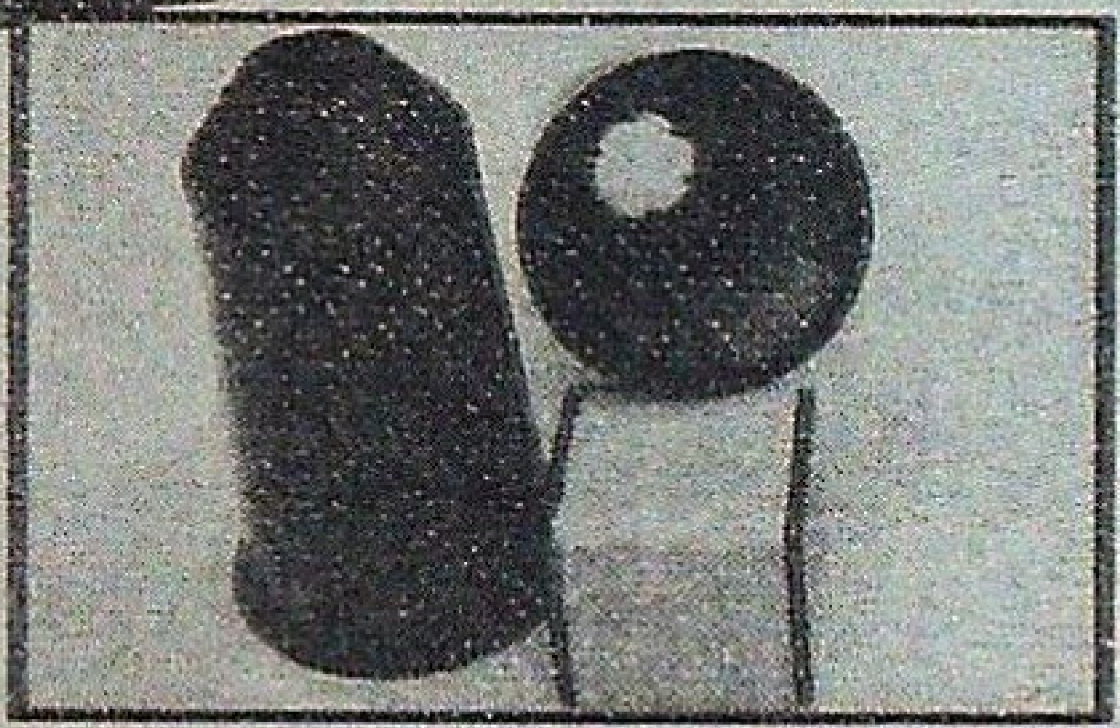
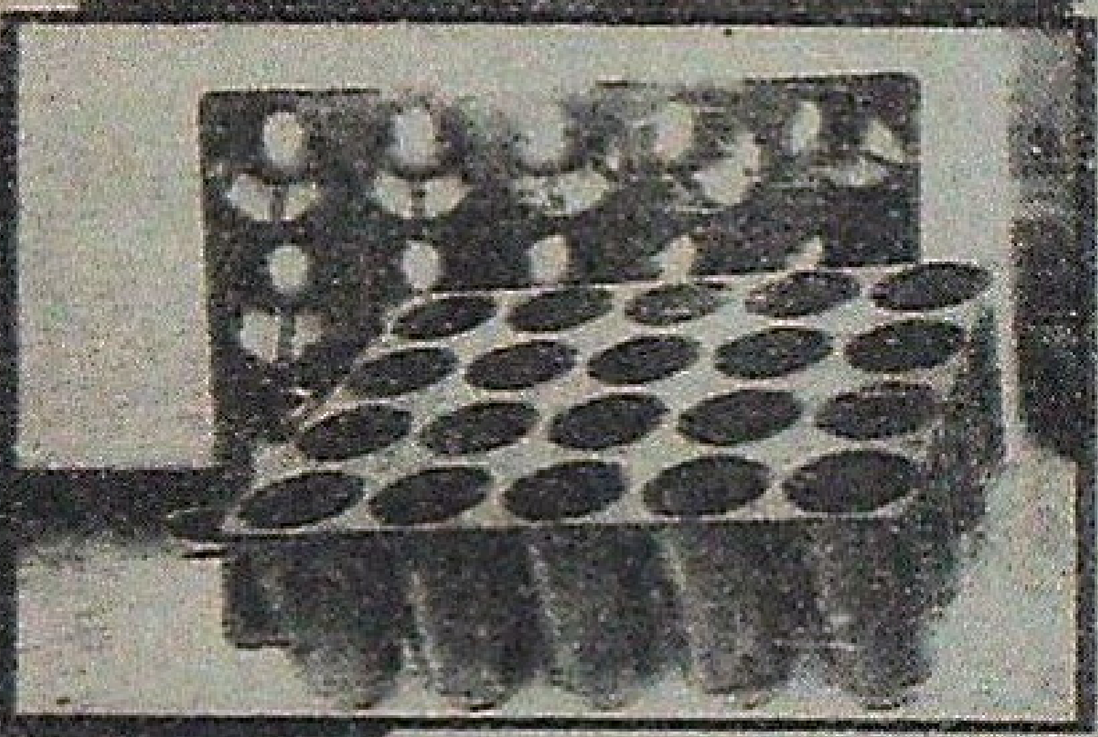




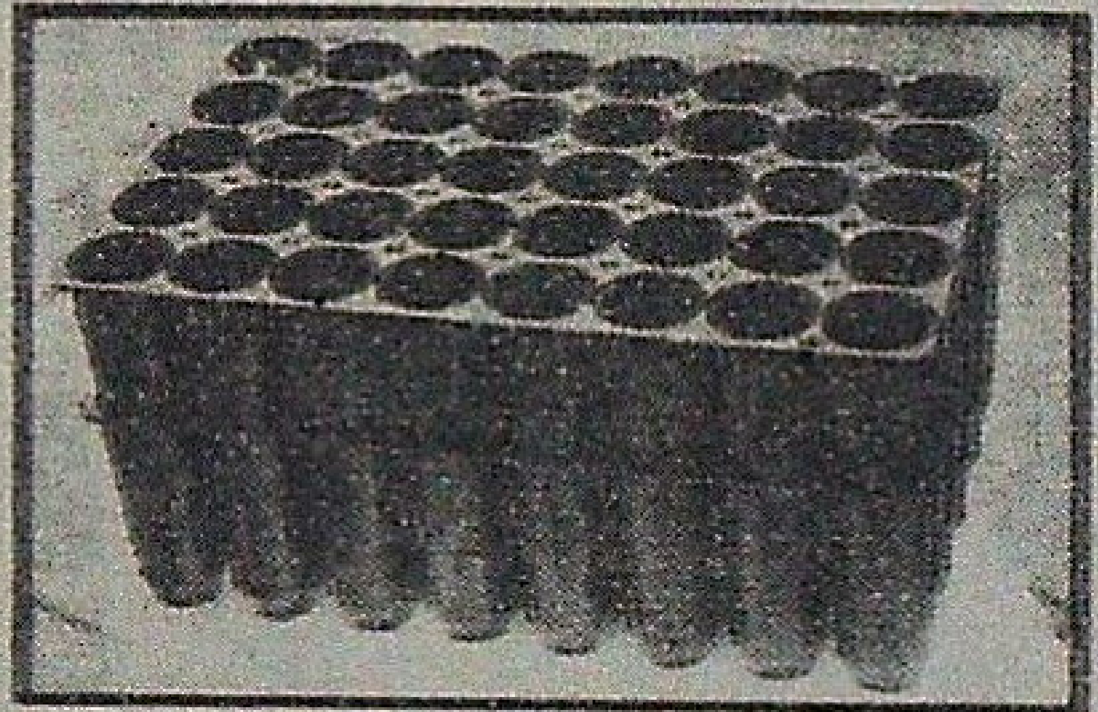
SC-110 Single Root Trainer
with Internesting.
Volume 110 c.c.



SC-150
Single Root Trainer
Volume - 150 c.c.



Compo - 150
Block of 20 cells
Volume - 150 C.C.



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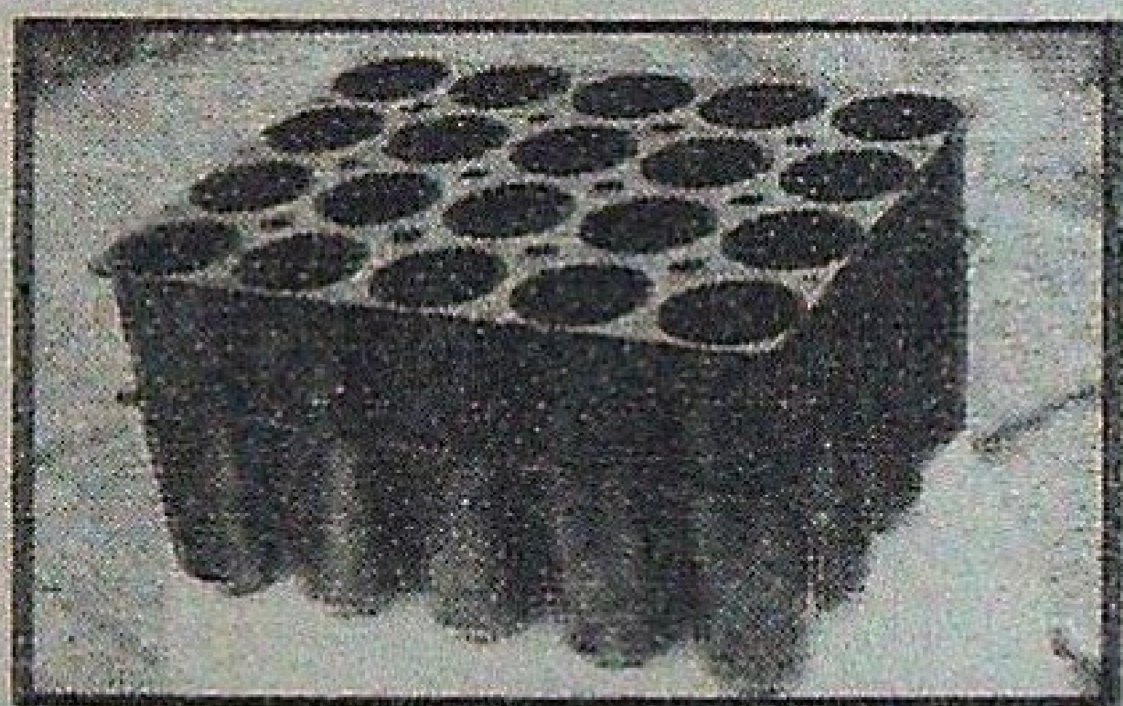
Volume - 110 C.C.



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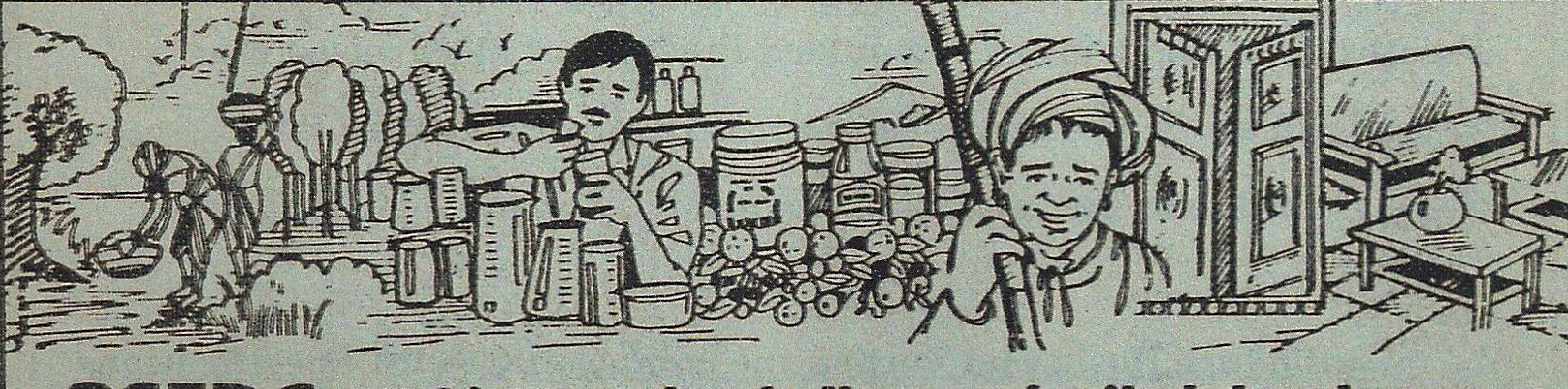

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Published by Rajesh, I.F.S. (Asstt. Silviculturist) from Forest Research Institute, Dehra Dun on behalf of the Board of Management, Indian Forester, Dehra Dun. Printed by S.K. Arora at Print World, 29-Rajpur Road, Dehra Dun. Hony. Editor : G.S. Rawat, I.F.S. (Head, Silviculture Research, Forest Research Institute, Dehra Dun).

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